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The Institute and Agricultural Progress

Anniversaries are occasions for retrospect and prospect. In recent months we have witnessed the pomp and pageantry of events associated with the celebration of Australia's Sesqui-centenary, and have been reminded of the unparalleled progress that has taken place in the building of the Australian nation since Governor Phillip's arrival at Botany Bay in 1788. Agricultural development in this country dates from July of that year when the first wheat was planted on land now forming part of the Sydney Botanic Gardens, and the notable advances which have been made in agricultural practice since that time have played a leading part in our national development. Indeed, but for plant and animal husbandry, civilization could never have attained to its present position ; hence to those engaged in the profession of agricultural science, the achievements of 150 years can have a very real significance.

But this anniversary marks also the transition from one era to another, the beginning of a new chapter in our history. The remarkable achievements of the pioneers of Australia, the varied problems still awaiting solution, and the means of approach to some of these problems were ably outlined by Professor A. E. V. Richardson in his presidential address to the Institute last year. In particular Dr. Richardson stressed the need for a well-balanced economy in this country, with both primary and secondary industries contributing their full share to bring about that progress and prosperity so essential for Australia's rapid development. The increased attention which the Council for Scientific and Industrial Research is now giving to the secondary industries indicates the view taken by the Commonwealth authorities in facing up to matters affecting national development, and the recent appointment of Professor Richardson to take charge of the Council's work in respect of problems in the primary industries augurs well for the future. Production potentialities and population-carrying capacity of our continent are questions which impinge closely on any considerations of migration and settlement. Both Dr. Richardson and Professor Wadham emphasized the position in this regard in addresses last year, and there can be no doubt that they viewed these and certain other questions as matters which could well receive some active consideration on the part of the Institute of Agricultural Science.

The Institute was established just over three years ago with aims and objects calculated not only to serve the profession of agricultural science in Australia, but to contribute in some definite way towards the advancement of both the science and practice of agriculture throughout the Commonwealth. In framing the Memorandum of Association, it was agreed that all possible functions which a professional unit might fulfil should be considered, but it was also realized that without the enthusiastic support and active participation by members in all such matters, the Institute could make little real progress. The mere accumulation of knowledge from individual effort in the course of one's daily work does not by any means ensure that in the long-run the welfare of the agricultural community is rendered unshakeable. It is in the direction of affairs, the focussing of knowledge so that it might be more consistently applied to current problems, the reassessment of the value of diverse policies, and the representation to controlling authorities of technical opinion in respect of lines of future action that a profession is capable of exerting its influence for the national welfare of the immediate future. But such power can never be wielded by any but a group well organized and strongly united on one common front of enthusiastic devotion to the objects for which that group stands. The inauguration of the Institute in January, 1935, was quickly followed by the formation of Branches in the several States, and by the publication of the Journal, which has appeared quarterly since that time. There was an obvious burst of enthusiasm over the birth of this new association of technical agricul-

turists, and aspirations soared high in all sections of the Commonwealth, but have those attitudes been maintained, and can it be affirmed that the Institute's " personality " is growing in strength and usefulness as time advances ? Although we can boast of a large corporate membership, the publication of a journal, and the holding of regular Branch meetings, our contribution to agricultural progress in this new era of Australia's history will be weak and ineffective without the loyal support and enthusiastic endeavour of *all members* of the Institute.

Animal Production

It is unnecessary to quote the relevant statistics to emphasize the importance to Australia of animal production or the proportion of agricultural produce finally reaching the market in this form. The market and the price which can be paid for any primary product are governed largely by the efficiency of its utilization in other industries. At the present time, in Australia, crop production methods are probably considerably in advance of those in the animal industries generally, and this is largely a reflection of the relative amount of experimental work conducted in each sphere. The steps to be taken in improving pastures can be stated much more definitely than can the methods of converting the grass so produced into a saleable article. The status of knowledge in plant nutrition overshadows that in animal nutrition ; the manurial trial has had precedence over the feeding test. Plant geneticists are often encountered, but where are their colleagues on the animal side ? In live stock papers, one may observe keen controversies on matters whose counterparts in agronomy are never raised for the reason that the facts are known.

To a certain extent, this position has developed from the attitude of the stock owners themselves. As a class they have been more interested in maintaining the *status quo* against disease, in cutting losses from death rather than in improved production per head. It is therefore not surprising that their veterinary advisers have tended to confine themselves to this aspect, for which work the training in veterinary science has been specially designed. The result is that of the experiments in animal production conducted in Australia, many have been done by agriculturalists mainly as utilization studies on pasture grass and other plant products. The team to tackle any organized scientific inquiry into animal production problems will therefore be all the stronger if it is selected from both professions.

It is heartening to know that the appreciation of this weakness in current research programmes has become more general. There has developed a

demand for initiation of scientific inquiry and experiment. The field for investigation is an intensely interesting and promising one, and the visit of Dr. John Hammond, the eminent investigator of animal problems, now in our midst, will do much to stimulate matters in this connection. In view of what has already been achieved from the association of fundamental studies with agricultural research, animal production investigations in this country may start from a relatively forward mark.

Agriculture and a National Policy*

By

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To the man in the street, as well as to those who rule the countries of the world of today, national defence is the outstanding problem. Australia is particularly interested, for, being the least densely populated of all continents, it is most likely to attract any people who might be land-hungry and, at the same time, it is most difficult to defend. An increase in population, especially rural, would be doubly advantageous for, on the one hand, the more fully utilized the country, the less it stands as a temptation and, on the other hand, a greater man-power would permit of greater defence forces.

Since total and rural population bear towards each other a definite ratio it follows that to increase the former, you must legislate to increase the latter. Certain aspects of this concern agricultural scientists particularly, and it is with those that this paper deals. The first matter is to ascertain the reason for the drift from the land and, admitting that transport facilities, the cinema and the radio have done much to improve conditions, it seems that the housing of both farmers' families and farm labourers needs earliest attention.

It is therefore proposed that type farm-homes should be planned, costing a variety of prices between, say, £200 and £1,000, and having, as minimum requirements for ordinary comfort, adequate water supply, septic tank, and some form of artificial lighting. Finance to enable these to be built should be supplied to farmers on the longest and easiest possible terms.

Training of Farmers.

If the son of a locksmith desires to follow this trade, or the son of the carpenter or doctor desires to pursue his father's avocation, care is taken by

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* Presidential Address to the N.S.W. Branch of the Institute on February 11, 1938.

the relevant trade union, if not by governmental ordinance, that adequate training is obtained. The farmer's son, if he does stay on the farm—and at least the oldest son usually does remain—is permitted by all concerned, and that means by the whole of the Commonwealth, to learn from his father and thus perpetuate his father's technique which, however sound it may have been, cannot in all the circumstances be the most modern or the most efficient.

It is easy to anticipate the comment that the States provide adequate training facilities, either free or extremely economical, of which the youth of the day fails to take anything like full advantage. This comment is true in every respect save the one word "adequate". It is true that the various State farms are languishing for want of trainees, but impartial observation will surely admit that there is very little to attract such trainees.

My second point is that conditions at farm training schools should be made more attractive, and the system of tuition more useful so that not only would the existing farms be filled, but more and more farms would be needed. Such farms need not be a great expense to the State, for they could, if efficiently planned and managed, be made largely self-supporting. In any event, of course, the training at such farms could with no hardship to the trainees and with great advantage to the State be made to take the place of the last few years of school. I am deeply sensible of the value of secondary education, but it might not harm the country if our farmers' sons had a little less Latin and a lot more farm-lore.

Remembering the locksmith's son and the doctor's son, it may be seen that no great adventure into heterodoxy would be needed to make the adequate training of would-be farmers a matter of the same compulsion as is now applied to other, less fundamental, less important, and certainly less difficult industries.

Research Services.

The defects of the present system are, it must be admitted, more a matter of degree than of kind. Despite this, of course, sheltering behind my early pleas of special privilege, I may essay to suggest even alterations of kind.

Searching for something that might be generally admissible, I am prepared to find that all departmental officers will agree that the departments are understaffed and underpaid. This remark is not intended to secure a laugh ; it is advanced as a serious fact that should be occupying a greater part of the attention of the authorities than can be the case. In every State, and in the Federal body which corresponds with the State departments, there is a constant loss of trained men attracted either overseas or to more lucrative positions in the commercial sphere. No blame can be attached to these men, even though it suits some in authority to hint that they are deserters. On the matter of understaffing, this is seriously aggravated by the practice of piling on to

trained technicians duties which might well be efficiently performed by non-technical men.

There is no need to recite the routine administrative duties, the police duties and the mechanical duties that fall to the lot of highly trained specialists in the services. These are known to you all—to most better perhaps than to the speaker. To perpetuate and to aggravate this situation is, as it were, to consider the employment of an Einstein to keep one's books or a Michael Angelo to paint one's fowlhouse.

The question of underpayment is, naturally, a delicate one, but there are professions, some not distantly related to our own, where the practitioners have been willing to sacrifice some of their finer feelings in order to achieve a finer income. Let those who wish to cry " Trade Unionism " exercise their lungs as they wish ; it remains an incontrovertible fact that until some concerted action is taken, agricultural scientists will suffer financially in comparison with doctors, veterinarians, engineers, architects or men of any other profession who are but differently, not more highly trained than the agriculturists. And of the question of the relative values of the respective services of these different categories one can only refer to the leading article of any current journal, which will assure the world that it is conscious that agriculture is the backbone, the life blood or whatever anatomical synonym you wish, of this country of ours. The backbone is weak, the life blood a trifle anæmic from the financial point of view. This condition must be ameliorated.

Assuming and, let us hope, merely anticipating attention to these matters, it will be seen not only that an increased staff will be needed, but also that conditions will be acceptable if not actually attractive. To cope with the former, the system of cadetships, to be awarded on merit by some scheme to be devised, must be intensified. There should always be in training rather more men than visible demands would suggest—this for obvious reasons. These cadetships would be tenable at the various universities, and even though some universities offer a number of overseas fellowships and research scholarships, the State should itself adopt the practice, not only with its most promising juniors but also with its senior men. Since universities recognize that they are the gainers by the sabbatical (and usually busmen's) holidays of its professors, it is not much to suggest that the departments would similarly, if not even more greatly, benefit from such similar system.

It must not be assumed that I imagine that the increasing of staff and the better payment of the personnel will put our research services into the highest class automatically, though, as will be seen, much of what is to follow, if not actually impossible to the present staff, would certainly be more possible if there were more workers. There are policy matters which need amendment, however, independent of any other alterations.

Perhaps outstanding is the degree of interstate overlapping which occurs in matters of research. Without being specific, you will all recognize many subjects which are undergoing investigation in each of the six States and by the C.S.I.R. without the interchange of information and ideas, and yet it must be quite obvious that a central clearing-house would confer economy of staff and therefore of money, and increase of efficiency. In non-agricultural research, how often does it happen that the observation of one is the inspiration of another ? It cannot be doubted that the same would occur in agricultural research. So far from finding any cooperation of this type, we find neighbouring departments diametrically opposed in their findings and their recommendations on a specific subject which cannot alter sufficiently with latitude or longitude to account for the differences of opinion. Pastures afford an excellent illustration. Department " A " says " Lime in all but exceptional cases ". Department " B " says " Never lime save in exceptional cases ". " A " says ammonia is the salvation of the mixed clover-rye pasture. " B " says ammonia is damnation to clover, and without clover there is no rye and no salvation. This difference of opinion even ventures to question the unquestionable value of other plant foods. The matter of which is right and which wrong is trivial ; the point is that one must be right, and accordingly, the other wrong on each separate point. How can this difficulty be better overcome than by the creation—under Federal or least interstate jurisdiction—of a central bureau of co-ordination which may eventually be able to prove that neither podsols nor potatoes change their habits when they cross the Tweed, the Murray, the Bass Straits or the 141st and 129th parallels of longitude ?

Another matter to which immediate attention must be given is that of the improvement and the standardization of experimental technique. So far, however, from seeing an irresistible demand from field workers for departmental sanction of the adoption of the statistically controllable trial, we had actually the experience at a recent public conference in one State of an officer criticizing that technique which, demonstrably, is alone reliable. This, of course, is an instance of an imperfect understanding of the difference between experiment and demonstration—a confusion, if you wish, between research and extension of which more will be said later. Facts elicited by such technique may, admittedly, be demonstrated to the farmers by a simpler method, but even there precautions should be taken to ensure that some non-controllable factor will not result in the demonstration seeming to favour the wrong treatment.

Soil surveys are urgently needed, their most practical value being the indication which they afford of the needs of the given soil type in relation to cultivation methods, crop suitabilities and plant food requirements. Soil surveys are, of course, under way in many parts of the Commonwealth, and I feel constrained to depart from my standard of steady condemnation to

compliment the Soils Division of the C.S.I.R. But soil surveys are slow and costly, and the demands of the farming community are urgent and insistent. Would it not, therefore, be of value to conduct—through the previously hypothecated bureau of co-ordination, perhaps—a nation-wide plant food requirements survey ? The logical objection to this lies, of course, in the wide range of soils on which a give crop will be grown. But is the range so wide or have not, rather, the farmers themselves by the unshakeable method of trial and error already conducted a soil crop suitability survey ? In general, it would be found that they have done and that, in consequence, this national plant-nutritional survey would have a wider applicability than might otherwise be the case.

In connection with this survey care must be taken to avoid the error of establishing a fact, and thereafter regarding that said fact as established with so much strength that it stands fast for ever. It is, perhaps, a pity, but it is true that the level of the fertility of any soil is not constant. Soil fertility as measured by productivity is a function of so many factors, chemical, biological, meteorological and human, that it is as variable as the weather itself, but it is true that the better a soil produces, the more rapidly its productivity diminishes and, the Law of Minima being still on the Statute Book, last year trial results need not necessarily be next year's truth. So we desiderate not only a nation-wide plant-nutritional survey, but a permanent national plant-nutritional survey. This may sound formidable, but it would be useful.

Aside from nutrition there is urgent need for the examination of varieties, the elimination of the least suitable and the limitation by legislative means if necessary of the number of permissible varieties. In this matter, of course, State rights would enter, for it does happen that within broad limits our political subdivision is also a climatic subdivision. The next step, thereafter, would be the imposition of further legislation prohibiting the sale of any save certified seeds, seedlings or plants of the permissible varieties.

This, of course, would impose hardships, but remembering that this is a matter of national policy, there is ample precedent for the imposition of individual hardship for the national good—and, in any event, it were a mild hardship to make a man change over to something that has been proven more productive and more profitable than that which it displaces.

Extension Services.

Whilst there is no need to endeavour to place extension and research in any order of relative importance, it must be admitted that the field man works under greater disadvantages. It is he who has to bear the literal heat, and often the literal burden of the outback day. It is he who is in constant contact with men who are not his intellectual equals, and who spends a great proportion of his time away from the comforts of his home. Working by day and often

travelling by night, this commercial traveller of science carries his samples in his brain, and even though he is willing to give his lines freely and without charge, he meets the same degree of sales resistance as does the traveller in hardware or the traveller in fertilizer.

Yet it is this man who has to translate into practical results of individual and national value the findings of his research colleagues to overcome the reluctance of the farmer—and the Australian farmer has no monopoly of this—to depart from his customary practices, and to break down the suspicions whilst retaining the goodwill of men who may be honestly unable to assess the merits of the revolutionary programme placed before them. Clearly, then, the extension man must be exceptional, possessing an equipment not necessarily better than that of the research man but clearly different therefrom. There are instances of men potentially brilliant on one side of the work who are employed on the other. This of course is not a matter needing any change of policy, but it is mentioned since there are awful examples of it to be found here and there throughout the Commonwealth. Field men, too, must be not permitted, but as a matter of policy expected to travel abroad so as to observe in other and older countries the reactions of farmers to expect advice, as well as, of course, details of practice.

Another need is for the establishment of a fixed departmental policy on all matters open to question. It would surprise you as much as it surprised me to learn in how many instances individual belief is permitted to overrule actual departmental findings, let alone generally accepted tradition. Since human beings are fallible and mortal, the dangers of this will be obvious.

Conclusions.

It may now be possible to build a single structure from the bricks which I have been flinging and perhaps also to adorn the finished product with a new idea here and there.

In outline then we seek to make life on the land more pleasant. We suggest that better training should be given to the farmers of the future. We ask that more men be engaged upon research and extension, and that their professional standing and their monetary reward be improved. Finally, we have suggested certain general lines of research which we believe might be followed with national advantage and, in one isolated instance amidst an orgy of spending, we have suggested that economy might, and that increased efficiency would follow the creation of a bureau for the co-ordination of experimental work.

We have made no suggestion as to how all this should be financed. This clearly, once the validity of the suggestions were established, would be the task of the governments of the day. It is, all too sadly, known that govern-

mental expenditure must come from taxation, and we already have, though we do not enjoy, the reputation of being amongst the most highly taxed of all peoples. Thus, I suggest, there would be little popular acclaim for, perhaps, an excise duty of 2% on all primary produce ; yet this would, on the figures of recent years, produce no less than £6,000,000, which, I believe, is three or four times the amount spent upon all the departments of today. Imagine, then, the effect of this if spent upon what we might term agricultural efficiency.

My general thesis, then, would suggest that we should spend, in the manners indicated, one-half of what we spend upon defence. Nationally we would gain in income and population. The effect of this upon world policy would be, as was suggested, to render this continent rather less attractive, for an empty country must always be a temptation.

One question remains untouched, and that is the significance of all this to the Institute of Agricultural Science. In our youth we have had to walk delicately, but now that we are out of the leading strings, may we not step out a little more boldly ? We know that we carry out " professional " work—can we not take steps to secure professional recognition ? How else may we ensure that the standard of the past will be maintained in the future ?

If the Institute of Agricultural Science is to take its due place in our national economy, if it is to take the lead in bringing about the few reforms suggested tonight together with all the others that may be needed, then it must assert itself, in the first place, by seeking and securing the same recognition that is granted to those other professions which are not assured by the Press as often as are we that they are the backbone of the country.

Investigations in the Pastoral Areas in Western Australia.

By

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With the aid of grants from the Australian Pastoral Research Trust Ltd. a series of studies is being made of several aspects of the sheep-raising industry in the semi-arid areas of Western Australia. Full accounts of the work undertaken are at present in preparation, but an outline of the problems, the methods of investigation and some of the results so far obtained may be of interest.

The pastoral areas of the State are, generally, those which lie north and east of a line joining Gantheaume Bay, north of Geraldton, and Israelite Bay,

east of Esperance. In these areas, rainfall is relatively light, and is unreliable in both the winter and summer rainfall regions ; also the possibility of serious droughts, such as that recently experienced, is never remote. Accounts have been given by Prescott[5] and Teakle[7] of the soils of these areas, and the vegetation has been recorded by Gardner and Kessell[2] and correlated with that of the rest of Australia by McTaggart.[3] A convenient classification of the natural regions has been made by Clarke,[1] and the areas with which these studies are particularly concerned lie within his " Murchison " and " North-West " divisions. As is rather to be expected, the individual pastoral holdings, averaging between three and four hundred thousand acres, considerable variability in vegetation, topography, etc., exists within each holding, so that the problems of the individual pastoralists vary from one station to another ; the general common factor limiting the pastoral exploitation of the country is that of the provision of stock water supplies, which are usually independent of local rainfall, supplies being derived from bores or wells. Botanical surveys of the vegetation do not of necessity throw much light directly upon its grazing values, or upon the problems of the pastoralist in utilizing available fodder to the best advantage. The point of view adopted throughout the whole of these investigations has been that the vegetation should be regarded in relation to its use by the animal. This of necessity leads to some apparent inversions of the usual findings. For example, botanically it may be true that " spinifex " is a dominant feature of the north-west, yet on stations considerably south of this region, even in the Leonora and Laverton districts of the North-Eastern Goldfields, " spinifex " attains pastoral importance in a negative sense in that 5,000 acres of it in a paddock of 20,000 acres effectively reduces the area there of immediate value for grazing. Similarly, the transition in the Murchison district between the eucalypt, or the " mallee scrub " zone and the mulga types, exists in effect as a belt about 100 miles wide, and thereby places the typical pastoral mulga areas considerably to the north of the line of demarcation shown in the Pasture Map of Australia which accompanies the C.S.I.R. Bulletin No. 99.

The Preliminary Survey.

An extensive but preliminary survey of the main pastoral areas of this State, excluding the Kimberleys, was made by the writer in 1935 through the courtesy of the Pastoralists' Association of Western Australia, in the company of Mr. W. L. Sanderson, then secretary of the Association. As a result of that survey, attention was directed to five main groups of problems—namely drought fodders, fluctuations in wool growth, suitability of sheep types, fertility, and the kangaroo (which, in Western Australia, has attained major importance as a pest in many pastoral areas and presents difficulties in its control or eradication on a different scale from those which exist in the eastern

States). A brief survey was also made of conditions in the Central and Lower Murchison. The State Committee of the C.S.I.R., to whom report was made, decided that in the meantime and for reasons of expediency, work should be concentrated on the question of the natural fodder reserves, drought conditions then being serious, and early in 1936 investigations were begun with the assistance of Mr. L. C. Snook, Mr. G. F. Melville and, later, Mr. A. J. Anderson and Mr. A. M. Stewart. (Later extensions of the work are providing information on the problems of fluctuations of wool growth, " canary stain " and the question of sheep type in relation to environment.)

At that time, prolonged drought had in most areas, especially the Murchison region, forced the stock to have resort to the less edible, or less palatable types of ground flora which ordinarily are neglected, and had caused some pastoralists whose holdings carried quantities of " mulga " to consider the economic aspects of cutting normally inaccessible fodder supplies to make them available to the sheep. The natural reserves of fodder plants were apparently being seriously depleted and heavy stock losses had occurred or were imminent, but the opportunity existed for studying the absolute drought reserves, their value and usefulness.

The main questions which present themselves under such conditions can be briefly stated :

(1) What precisely are the natural drought reserves ?

(2) Even within one plant species, the stock apparently show marked preferences for certain forms ; how significant are the variations in edibility or palatability, and what influences them ?

(3) What are their real values as fodders, and do they require some supplement ?

(4) What are the best methods of utilizing the drought fodders, and can any alterations in sheep husbandry and station management be made so that they are used more efficiently and economically ?

(5) How severe a grazing can the bushes and shrubs withstand, and how serious is the depletion of plant reserves ?

(6) What are the conditions and chances of regeneration ? In addition there is the serious question :

(7) Whether the pastoral areas of Western Australia are likely to experience such a tragic history of exhaustion and erosion as that reported by Ratcliffe[6] in other areas of the Commonwealth.

To several of these questions the practical experience of pastoralists suggested answers, but the variation in common names of plants as well as that of local conditions emphasized the necessity of scientific investigation, irrespective of whether any results which could be translated into practical policy might be forthcoming in time for application during the current drought conditions.

The preliminary surveys had indicated that in the first instance attention could profitably be directed to three main areas, the mulga country of the Central Murchison, the North-Eastern Goldfields where the influence of the

salt lake systems imposes a different set of problems in the extensive saltbush plains which dissect the mulga country, and the spinifex regions of the north-west.

Ecological Survey in the Murchison Region.

The drought conditions were particularly severe in the Murchison region and, facilities being provided by the Boolardy Pastoral Company, a detailed ecological survey was made of an area on Boolardy station with the object of acquiring knowledge of the plant associations in that region.[4] The site selected was intersected by the Roderick River (which in that region forms generally the northern limit of the transitional belt from the lower acacia scrub to the true mulga zone) and included the following main habitats :

(*a*) The general plain, with *Kochia, Atriplex* and *Rhagodia* the most common plants with some low growing stunted mulga.

(*b*) Higher country with a sparser vegetation, Snakewood (*Acacia eremæa*) and Poverty bush (*Eremophila pterocarpa*) predomianting.

(*c*) The river country, with *Casuarina* sp. and many species of shrubs, but no mulga.

(*d*) The smaller streams and " washes " in which a marked succession of plant species is found from their sources to their junctions with the river ; at the source, various forms of mulga (*Acacia aneura*) are predominant ; when a definite channel is established, curara (*Acacia tetragonophylla*) becomes prominent.

(*e*) The lower flood plain, characterized by mulga thickets, and belts of the quite edible curara ; *Acacia craspedocarpa* and *Acacia Grasbyi* (" Minerichi ") are also noteworthy. In addition to these a common association in the Murchison is that of the Bowgada or Wandarrie (*Acacia linophylla*), with which occurs the perennial " Wandarrie grass " (*Eriachne* spp.) in patches or belts.

Information obtained in this survey has been used as a basis with which material and data from other traverses are compared, and the site selected is intended to serve as a reference for further observations on regeneration of the perennial vegetation and on the appearance of annual species when rains occur. Detailed studies have been made of locations in the spinifex country near the De Grey River, and further general surveys have now been made during extended traverses of other pastoral areas including the Ashburton, Gascoyne and Pilbara districts and also of the Wiluna area ; from these, as well as the Eastern Goldfields, material has been collected for botanical study and chemical analysis. Relevant information on sheep husbandry and station management has also been collected to the end of securing pastoral utility maps of the chief pastoral areas of the State.

The ecological survey and the general observations on the top-feed were followed by a close study in the field of the behaviour and preferences of sheep for which mulga was being cut ; from this, differences in palatability were definitely established and the reasons sought in chemical analyses. These studies were in time followed by feeding trials on the station, in which a number of sheep were accommodated in temporary yards, and the adequacy of cut mulga as a drought fodder was considered. At the same time the preferences

observed in the field were checked by offering the sheep various kinds of cut scrub.

At the present time a similar course of study is being made in the spinifex areas of the Port Hedland district.

The results so far obtained can be discussed, in the main, as they bear upon conditions in the Murchison which, from expediency and because of facilities, were first investigated; they can be considered in relation to the questions proposed above.

Nature of the Drought Reserves.

The limiting factors are water and the accessibility and palatability of the vegetation. Within reasonable grazing distance of a good water supply, sheep will generally follow a definite sequence of choice of plant types towards the least accessible portions of the edible shrubs and trees, or towards the least palatable species.[1] In extreme conditions, stock, if "forced" on to them, may even eat plants ordinarily considered inedible—e.g. some "Poverty" bushes (*Eremophila* sp.)—or the foliage of some of the least edible forms of "mulga". The drought-carrying capacity of a station, or of a paddock, must be considered in respect to water, and to the availability and edibility of plant species and varieties. The vegetation has been classified in relation to these factors.

Variations in Edibility.

Most attention has been directed towards the differences existing within a species. In mulga, palatability under field conditions is related to the amount of "resinous" secretion on the phyllodes and stems; this in turn varies with the age of the plant, with the subspecies or variety and its habitat, and with seasonal conditions. Analyses show that a close negative correlation exists between "ether extract" and edibility; Melville[4] has found, for six varieties of mulga from one paddock in order of decreasing edibility in the field, ether extract figures (%) 6·5, 9·5, 10·6, 10·0, 11·7, 12·0, and in another paddock, 5·7, 7·1, 8·2, 8·9, 7·32. This situation has been confirmed by Snook (unpublished).

Values as Drought Fodders.

Previous practical experience in drought times had shown that many of the plants were valuable drought fodders. Information was then sought as to the composition of a number of species from different stations. Snook (unpublished) has paid special attention to the mineral contents of various acacias and other perennials; summarized briefly, his results show for seven

[1] Under drought conditions, many shrubs shed their leaves and become dormant; this adds to the rapidity of the reduction of available fodder supplies.

edible and four inedible mulgas : total ash, average 4·8%, calcium just under 2% CaO, and P_2O_5 average 0·25% for edible and 0·16% for inedible types. This analysis also tended to establish the existence of the relatively high crude protein figures for the mulgas (averages : edible types, 10·4, inedible types, 8·4) and for *Atriplex* spp. and *Kochia* sp.

The results of chemical analyses though suggestive, did not throw light upon the question as to how far mulga alone could sustain sheep, so that feeding trials were begun at Boolardy on 24th July, 1936. In them, fifteen station sheep were introduced to conditions of confinement in small pens and hand feeding ; ten of them were selected for individual feeding with cut mulga. The sheep were given bundles of small branches of mulga twice daily, the bundles being weighed before and after each meal. At the beginning of the trials, the average weight of the ten sheep was 70·8 lb. ; after fifteen days with an average daily consumption of 3·0 lb. of mulga per day, the average weight was 75·3 lb. From then on, some of the animals were used for other observations ; without presenting details of the series of trials which altogether lasted for nine weeks, it can be stated that the sheep fed on mulga alone showed an average increase in weight of 11·7 lb. on a daily ration of just over 3 lb. of mulga. From the 13th to 27th September, five sheep were given 4 oz. of wheat per head per day and in addition consumed 3·1 lb. of mulga, and showed an average increase of 3·8 lb. in weight ; during the same period, the other five animals on mulga alone ate 3·3 lb. per head per day, and made an average increase of 2·2 lb. in live weight.

Admittedly the numbers of animals involved in the trials were small, but the results strongly suggested that sheep under confined conditions would not only subsist, but would increase in weight on about 3 lb. of mulga per day, that their health and general condition would improve, and that the consumption of mulga could be reduced by the addition of a small supplement of grain. Throughout, a notable improvement in wool growth was manifested.

Methods of Utilizing the Drought Fodders.

The different sets of conditions obtaining in any area, even in a single paddock, preclude any general answers to this and the later questions ; the investigations, however, allow of certain suggestions relative to some of the main features.

From the practical point of view, the major considerations in the avoidance of stock losses are probably those of the economic aspects of agistment, supplementary feeding and the use of " new " (i.e. hitherto ungrazed) country, with water supply an important factor in every situation. In Western Australia, the amount of fodder conservation from good seasons for bad is negligible, but in the " top feed " areas the edible mulgas provide a natural reserve of a protein-rich food which is ordinarily out of reach of the stock, but lopping or

felling the trees involves additional labour costs. Hand feeding with purchased supplements is also an expensive undertaking, and much further study is necessary before reasonable recommendations can be made for Western Australian conditions, beyond this that the preliminary investigations show that in the spinifex areas a protein supplement may be necessary, while in the top feed areas the addition of a carbohydrate supplement is more likely to be economical. In any case, a prime question is whether the food supplies remaining on the station can be used more effectively.

The feeding trials under close confinement at Boolardy did not reveal how much of the improved condition of the sheep could be attributed to the very fact of confinement, but served to emphasize the necessity of paying close attention to the habits of the sheep while grazing. Under ordinary free ranging conditions, and especially during drought periods, the stock expend a considerable time and portion of their energy in moving between one bite and another, and between feed and water. The feeding trials showed that the actual requirements in terms of mulga were low, and it was therefore suggested that, under drought conditions, probably one of the greatest economies which could be effected would lie in the conservation of the energy expenditure of the animals, this leading to a conservation or reduction in the top feed used or made available. In relation to this view, concentrated cutting of top feed would appear desirable, and cutting of odd trees at wide intervals—encouraging the sheep to travel—undesirable and wasteful. The conditions under which this form of economy could be applied in practice would vary considerably according to the density of the top feed vegetation and its kind.[1] Following upon the results of the trials on the station, the Boolardy Pastoral Company elaborated a system of management in which the requirements in terms of cut mulga and of labour were greatly reduced by " holding " the sheep on the waters on the one hand, and on the cut mulga on the other. At the same time, losses were greatly reduced and the sheep were maintained in strong condition.

Grazing, Depletion of Plant Reserves, Regeneration.

Conclusive information on these questions will of course not be forthcoming until some time after the drought has broken, but it has been possible to make relevant observations. Much of the accessible bush vegetation (e.g. *Atriplex*) has apparently been killed by excessive defoliation and " pruning " by grazing amounting to overstocking, or by lack of water, or a combination of both ; some, though severely eaten back and apparently dead, has responded to odd showers. Larger bushes (e.g. " Blue " or " Sago " bush, *Kochia* sp.), of which only the peripheral foliage and small stems have been eaten, also have

[1] The provision of more watering places as a drought measure is an expenditure not likely to be contemplated by pastoralists, except towards the exploitation of new country, yet it would encourage the form of economy suggested as well as the stock to drink more frequently.

shown a marked ability to respond, while others such as the curara (*Acacia tetragonophylla*) quickly react to improved water relationships.

The question of the regeneration of the mulga is of great importance particularly since in many areas intensive cutting has occurred primarily for mine requirements for timber and charcoal. Melville[4] has gained evidence that stocking has probably little effect on mulga regeneration, since young mulgas (less than four inches in height) even of the most edible varieties, are definitely distasteful to stock, and are hardly ever touched, probably owing to the greater amount and possibly different chemical nature of the exudate; not until the height exceeds about twelve feet can the tree be considered edible.

Adult mulgas have extensive lateral root systems which restrict neighbouring young trees in the competition for moisture, and it is usually in areas which have been cut over in the past that marked regeneration has occurred. It should be noted, however, that seasons favourable to germination and growth are relatively infrequent and occur only when the country has been flooded or when summer rains have been bountiful.

Exhaustion and Erosion.

At this stage, only impressions arising from observations over a short period of time in certain areas can be recorded.

Heavy grazing of saltbush types of vegetation may lead to denudation, especially in the eartern portions of the Murchison region; in parts of these areas also, as well as of the Central Murchison, where conditions are marginal to mulga thicket formation, scrub cutting should be conducted with caution if serious soil erosion is to be avoided. In the other areas, mulga regeneration is apparently quite rapid with favourable seasons, and where scrub cutting has occurred there are quantities of *débris* and fallen branches on the ground which form an effective protection against erosion; there is also a profusion of inedible shrubs and trees. In addition to these, the conditions throughout most of the Murchison are dissimilar to those of South Australia in the different soil type and in the nature of the soil profile which forms a definitely inhospitable environment for rabbits.

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The Wine Industry*

By

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Few industries can claim a greater antiquity than that of wine. Since the dawn of Art, the vine and its fruit have been used decoratively by artist and sculptor. The Egyptians, Persians, Phoenicians, Greeks and Romans were experts in the art of making and drinking wine. Even Noah combined the professions of shipbuilding and œnology. The Romans were particularly skilled viticulturists, and the cultivation of the vine followed everywhere in the wake of their conquests. Wine is the oldest alcoholic beverage known to man, and its origin is now lost in antiquity.

World Distribution.

The vine thrives well over a great range of climate, soil and latitude. It is seriously affected, however, by extremes of heat, cold and altitude. It is best adapted to the climate of the Mediterranean, which is mildly cold and wet in winter, and relatively warm and dry in summer. It is grown successfully in the countries surrounding the Mediterranean, California, Chile, Argentina, the Cape Province in South Africa, and the southern and south-eastern districts of Australia. The following are the production figures (average) for the years 1926-1930 in different countries:

Country.	Production of Wine per Annum. (In Million Gallons.)	Consumption per Head. (In Pints per Annum.)
France	1,139	455
Italy	866	303
Spain	481	154
Algeria	248	—
Roumania	143	26
Argentina	143	—
Portugal	132	99
Yugoslavia	74	17
Chile	71	—
Hungary	55	57
Greece	52	62
Germany	40	7
Bulgaria	39	38
Australia	17	6
South Africa	18	15
South Australia (Beer)	5	70

Moreover, France has nearly four million acres under vines. This is remarkable when considered with the fact that for this year the total area

* Address delivered to the South Australian Branch of the Institute on December 3, 1937.

cropped in South Australia is not quite so large. It makes our total of 33,850 acres of wine grapes seem very small.

The Vine in Australia.

The history of vine culture and wine making in Australia is one more record of the vision, fortitude, determination and endurance of the old pioneers, who, hampered by lack of finance and technical knowledge, handicapped by criticism,

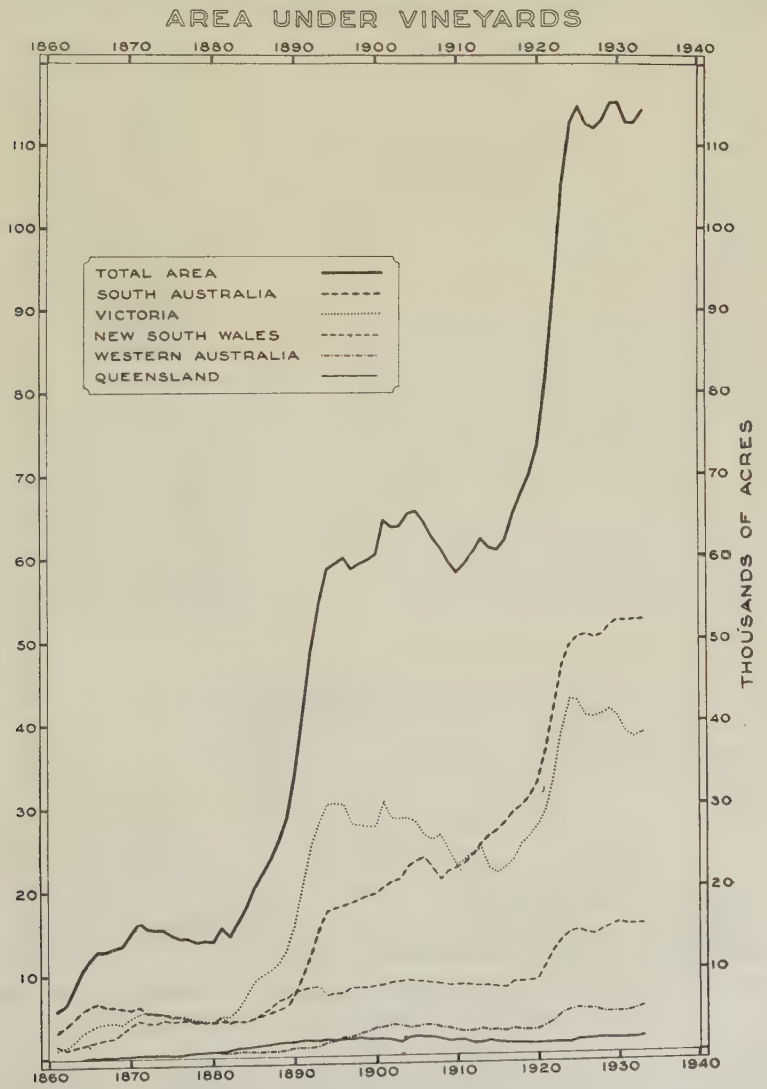

FIG. 1.—*Area under vineyards, in thousands of acres, for the entire Commonwealth and for each wine-producing State* 1861-1934.

born of ignorant prejudice, won through and laid the foundations of the present industry. It is a volume in itself and cannot be passed over without brief reference.

In 1788, vines of various sorts were brought from the Cape of Good Hope to Sydney, and in 1790 it is recorded that there were eight vines growing in

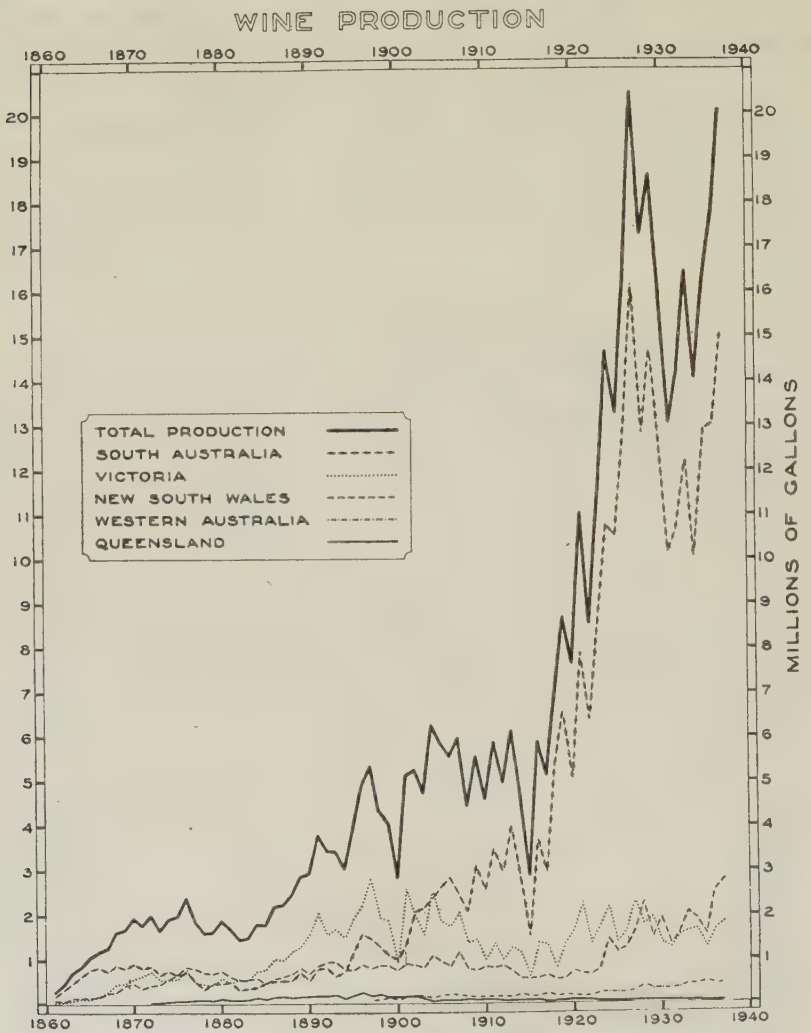

FIG. 2—*Production of wine, in millions of gallons, for the entire Commonwealth and for each wine-producing State, 1861-1937.*

Norfolk Island. In 1815 John MacArthur, now famous as the founder of the Australian merino, planted a vineyard at Camden, N.S.W., and so was the first maker of wine and distiller of brandy in Australia.

It is recorded that in South Australia, in the year 1841, John Reynell planted a few acres of vines from which he made wine in 1843, when further planting was undertaken. Two years later, Anstey planted ten acres at Highercombe.

Most of the cuttings planted were obtained either from MacArthur at Camden or from the Busby collection in N.S.W. Some were also imported direct from the Cape. By this time the industry was past the experimental stage, the soil and climate had proved to be most suitable for the cultivation of the vine, the wines were good, and further planting was enthusiastically carried on ; while in 1850 there were only 197 acres in cultivation, in 1860 the acreage had increased to 2,201.

From figures obtained from the Commonwealth Statistician, two graphs have been prepared, one of vineyard acreages and the other of wine production. From the former, it may be noted that in 1861 the South Australian acreage was double that of N.S.W. and nearly treble that of Victoria. In 1882 the acreage of these three States was almost equal, Victoria in the lead, and Queensland and Western Australia just coming into the picture.

About this time the Victorian Government sought to stimulate planting by the free distribution of rooted vines and the payment of a cash bonus for the financial assistance of prospective vignerons. The result of this policy was a rapid increase in area of from 4,900 acres in 1882 to 30,275 in 1894. The inevitable result was a badly glutted market in wines and vine fruits.

In 1887 the irrigation settlements were started on the Murray at Mildura and Renmark by the Chaffey Bros. You are all familiar with the history of this venture, and how after many years of financial and political vicissitudes, Mildura and Renmark are now two of the most prosperous rural towns in Australia.

In the early eighties, *Phylloxera* was discovered in a Geelong vineyard. From there it was carried to Bendigo and was found in the Goulburn Valley in the nineties ; from there nearly every wine-growing district in the rainfall areas in Victoria has become infected. The destruction of thousands of acres of vines resulted, and brought about a decline in vineyard areas until 1915, when increased planting again became manifest.

It is interesting to note that South Australia and Western Australia are fortunately free from this insect and are using every endeavour to prevent its introduction by stringent legislative enactments. It has not been found in any of the irrigation districts. South Australia is, I believe, still one of the few remaining vine-growing countries that has not yet been ravaged by this destructive pest. As yet free from this scourge, planting in South Australia has steadily and consistently progressed until the present total of 56,122 acres has been reached.

Wine Production.

In the second graph it appears that, although in the sixties the South Australian production of wine was far greater than either that of Victoria or N.S.W., its progress became much slower than that of its eastern competitors, and by the early eighties it had dropped well behind into third place. A glance at the Victorian figures on the graph will show the great increase in vineyard areas as a result of the financial encouragement given by the Government.

In the wine production of Victoria the destructive effect of *Phylloxera* can be noted, dropping to its lowest point, 605,000 gallons, in 1915. In the first graph the loss caused by *Phylloxera* was to a certain extent offset by replanting on resistant stocks, but more largely by the plantings under irrigated conditions. Except for seasonal variations, there has been a continuous increase of wine production in South Australia since about 1882, and of the total wine made in Australia last vintage, 20,060,502 gallons, South Australia produced 15,026,500 or about 75%.

Value of Vine Industries to South Australia.

The grape growing and wine making industries are valuable assets to this State. Viticulture is one of the rural industries in which the value of production per acre is relatively high, and where considerable labour is employed. Viticulture may be successfully practised in low rainfall districts where moisture requirements can be supplied by irrigation, as well as in those areas where the annual average rainfall is not less than 20 inches, soil and location being suitable. It therefore follows that provided a payable market awaits the final product of the vine, whether it be fresh grapes for table purposes, dried, or made into wine or brandy, every acre utilized for viticulture assists in obtaining this objective. By the exportation of these commodities, the maintenance of a favourable trade balance overseas is assisted.

In very approximate figures, the cost of growing and reaping an acre of wheat is about £1, that of growing and harvesting grapes in the rainfall areas about £5 to £7 per acre, and under irrigated conditions about £20. It has also been determined that the total capital invested in wineries and distilleries is almost as great as that invested in butter, cheese and bacon factories, grain mills, breweries and dried fruits, jam and canning factories ; that the costs of material, fuel, light, etc., excluding wages, are nearly 20% greater than those of the butter, cheese and bacon industries, and nearly 10% greater than the milling, brewing, drying and canning industries. In the wages and salaries, the percentage is greater in comparison with the former and less with the latter group.

In the value of gross output, that of the wineries and distilleries is nearly a quarter greater than that of the butter, cheese and bacon factories, nearly

double that of the flour mills, and three times as great as the combined output of the breweries, dried fruits, jam and canneries. For the vintage 1937, about 70,000 tons of grapes were used for wine making.

South Australian Exports.

Of the total wine and brandy made in S.A., about 10% is consumed locally and the balance exported. This is only an estimate, as the correct figures are unobtainable. For the year 1936-1937, the exports of wine from S.A. overseas were 3,679,365 gallons, valued at £955,033 (90% of the total exported from Australia), and for the same period 116,768 proof gallons of brandy, valued at £80,141 (87% of the total exported). The interstate exports were 1,894,207 gallons of wine and 169,256 proof gallons of brandy, making the total value of all exports over £1,500,000.

During the same period, the Commonwealth Government collected in revenue in Australia from fortifying spirit the amount of £257,944, and from brandy £242,586.

Problems of the Industry.

In South Australia, the vine flourishes; the climate is favourable for regular cropping and generally unfavourable for the development of fungus diseases. Except for frost damage in certain localities, the only failure occurred in 1915 following the 1914 drought. Apart from *Phylloxera*, which has not yet appeared, all the diseases to which the vine is subject are, in view of the climate, easily controlled if the necessary treatment be given at the right time.

There still remains unlimited scope for research and improvement in the technique of wine making. The main worries, however, are financial, legislative and commercial, and the difficulties of balancing supply with demand.

That the capital invested in wineries is over £1,000,000, and that raw material, etc., to the value of £1,500,000 is purchased by the wineries annually is rather remarkable, considering that most of the proprietary wineries are owned by private companies, which, with the assistance of the banking institutions, have built up these businesses without the help of outside capital. Generally speaking the industry is under-financed.

The liquor laws in all the States in Australia are a clumsy compromise between the doctrines of the prohibitionist and the desires of the moderately inclined, with the result that trading is restricted and sometimes driven into underground channels, and no one is satisfied. The hours of trading are inconvenient to the public, and the English system could be adopted with advantage. The six to eight exemption for light wines in South Australia is a move in the right direction.

Some years ago, in three of the States, we were confronted with the paradox of the Governments on the one hand spending large sums of money in the planting of wine grapes and the erection of wineries, and on the other, restricting the channels of sale and distribution.

Since its inception, the industry has passed through long periods of depression, followed by long periods of great activity. When demand overtakes supply, planting immediately starts. In the rainfall areas, about five years would elapse before the result of the first planting would be felt. It then might be another five or ten years before the market began to become overloaded, and then there are five years of planting still to come into bearing and overload an already glutted market. In the irrigated areas, vines come into full bearing much more quickly.

In spite of the progress that has been made in the export trade in the last ten years, it certainly looks as if for the next few years production will be greater than market requirements. The trade with Great Britain has been developed with the assistance of Empire preference, the export bounty, and the depreciated Australian currency. The loss or adverse alteration of any of these would greatly affect the stability of the trade. Australia has her share of the New Zealand market, and is shipping wines to Canada, where there are distinct possibilities of increasing exports.

Some Length of Day Effects in Plants

By

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Within recent years a vast amount of research work has been carried out on the influence of light on plant growth. The importance of this field is evident from the extensiveness and the nature of recent reviews which are listed at the end of this article. " The Biological Effects of Radiation " is a symposium of 43 papers, each with a substantial bibliography. " The Rôle of Light in the Life of Plants ", by Burkholder, is a review of 600 papers. There have been numerous reviews of special phases, including photoperiodism, in recent years. In these reviews the problems of the influence of light on plant growth and differentiation, on the many plant processes and phenomena are treated from a number of viewpoints, including the influence of light intensity, spectral composition, wave length and duration. An understanding of these wider aspects is necessary for an appreciation of the more restricted field of photoperiodism or length of day responses.

The length of the daily period of light affects both the growth and the differentiation of plants. " Growth may be defined as the irreversible increase in the size of a plant or its parts ; new protoplasm is synthesized, cellular boundaries are extended, and weight is increased."

Light is not necessary for the growth phase of a plant's activity, and organic enlargements occur mostly in the dark. Exposure to light causes a characteristic effect on the growth of plants—" the light growth " reaction. The growth rate is first depressed on illumination, but later returns to normal. In the date palm light completely inhibits growth.

However, light is essential to the differentiation or developmental phase of plant life. Differentiation in contrast to growth may be viewed as a developing process whereby are obtained the forms and structures which are characteristic of different kinds of cells, tissues, organs and species. Plants grown in complete darkness exhibit attenuated stems and thin rudimentary leaves. In many plants foliar development is limited to the plumular hook. The tissues are thin walled, loosely arranged and less differentiated than in illuminated plants. The plant lives entirely on stored products of the seed, tuber or corm as the case may be and, if the stored food is sufficient, may live through several generations. Although chlorophyll is absent in the majority of plants, a few such as conifers develop chlorophyll. Differentiation of blossom buds is entirely inhibited if the whole plant is in complete darkness, although blossoms may form on darkened branches if the remainder of the plant is illuminated.

Plants which are grown with very little illumination are profoundly different from those grown in complete darkness. An illumination period of two minutes per 24 hours from an 80 c.p. lamp caused *Vicia* and *Pisum* to develop out of the plumular hook and to begin the expansion of the leaves. Ten minutes' exposure gave leaves almost as large as one hour's exposure. This exposure was also responsible for chlorophyll development in these genera.

Light, then, has a notable effect upon the degree of differentiation of plants and thus exerts a marked influence on morphology. Some influences of the daily duration of light upon morphological changes and seasonal development of plants are described in the following sections.

The Photoperiodic Classes.

The method adopted in studies of photoperiodism is simply to regulate the length of daily illumination by either enclosing with black cloth and thus reduce the hours of daylight, or to supplement the hours of daylight by artificial illumination. The study of supplementary illumination dates from 1861, but it remained for Garner and Allard to demonstrate the importance of the relative length of day for the vegetative-reproductive cycle in plants. Their first work was published in 1920, which, confirmed and extended by numerous researches, has resulted in the classification of plants into what are now known as the photoperiodic classes.

In the first group of plants, the short-day plants, flowering is readily induced by exposure to short days usually of 10 hours, but flowering is indefinitely postponed by exposure to long days. In a second group of plants, the long-day plants, flowering is brought about by exposure to long days, but is indefinitely postponed by exposure to short days. In a third group, flowering occurs under the influence of both long and short days. This constitutes the neutral or indeterminate group to which belong most everblooming types of plants. To test a plant for its photoperiodic group, it is only necessary to grow it under daily exposures of 10 hours and 18 hours *per diem*, and observe under which, if any, daily light period flower formation is accelerated.

A critical length of day has been determined for many plants, and such a critical photoperiod is believed to exist for most plants. Nevertheless, short-day plants flower readily under a photoperiod shorter than the critical, but in day lengths exceeding the critical they show extensive stem elongation without flowering. On the other hand, long-day plants do not flower in a photoperiod shorter than the critical and, in typical examples, tend to remain in the leaf rosette stage. When the critical photoperiod for this class of plants is reached and exceeded, long-day plants produce a rapid elongation of the axis, followed by profuse flowering. Since several of the head type of vegetables are long-day

plants, it is readily seen how important photoperiod is for the objectionable characteristic of bolting to seed. The choice of the planting time to ensure a correct photoperiod is an important factor in the culture of herbaceous crops.

The Photoperiodic Control of Blossoming.

The critical relation between photoperiod and differentiation of blossoms admits of considerable manipulation of the blossoming habit of plants. Plants can be kept in the vegetative stage for long periods of time by providing the appropriate photoperiod. Their blossoming may be made more profuse, or earlier or later by adjustment of the day length. The annual cycle of plant activity can be greatly shortened or almost indefinitely lengthened. Depending upon the length of day, certain annuals may complete two cycles of growth in a single season or may show some of the characters of perennials. Typical annuals or perennials, in which intense reproduction has been induced by a favourable day-length, may be rejuvenated by transference to the day-length which promotes vegetative activity. Further, both long- and short-day plants may assume, by adjustment of the day length, that delicate balance between vegetative and reproductive activity which permits of everblooming. Everblooming is, nevertheless, more characteristic of the indeterminate group of plants.

From what has been stated, although in a condensed form, in the foregoing, it will be seen readily that the annual, biennial and perennial nature of a number of plants is a reaction to the prevailing seasonal photoperiods. Whether a plant is a spring, summer or autumn flowering plant, or has an everblooming characteristic, is to a very large degree its normal or natural response to the seasonal length of day. Each variety and species is likely to be strikingly individualistic in its photoperiodic requirement. Hence this factor is fundamental to the appraisal of early and late maturing varieties. Not only is the adaptation of crop plants to definite regions and to certain seasons a response to photoperiod at least in part, but the wider field of the ecological distribution of plants throughout the world is to be regarded as a response to the same influence.

The Influence of Photoperiodism on Periodic Growth.

It now appears probable that the periodicity of the growth of trees is in large measure a response to the seasonal march of photoperiods, since these are known to influence the separate factors of bud break, blossom bud initiation, abscission of fruit and leaves, dormancy and rejuvenation.

According to Garner,

" Allard has been able to show that woody plants are capable of responding to photoperiod in the same manner as herbaceous species. Shrub-althea, *Hibiscus syriacus* L., was found to be a long-day type with a critical photoperiod of 12 hours or slightly less. Flowering was suppressed for the four years of the test by a 10-hour day but was abundant

with photoperiod of 13 hours or longer. Bougainvillea, *Bougainvillea glabra* Choisy, responded as a short-day type, flowering abundantly with a 10-hour photoperiod. Its critical photoperiod appears to be somewhat in excess of 12 hours. Turkscap hibiscus, *Malvaviscus conzatti* Greenman, proved to be a day-neutral in the latitude of Washington, D.C.

" At Leningrad, Bogdanoff subjected 1-2 year-old seedlings of broadleaf and coniferous species to the normal day and to regulated photoperiods of 13 and 9 hours under outdoor conditions. With a shortened day length, the period of growth of all species was reduced, and subsequently there was earlier emergence from dormancy. Larches from southern latitudes showed very late growth under the normal day, but under a short photoperiod vegetative activity ceased six weeks earlier. Southern forms of pine made scant growth under the normal northern day, and were injured by winter cold, whereas exposure to a shortened photoperiod produced good growth and the trees stood the winter well. Employing similar methods, with addition of supplemental artificial illumination and localized treatments of the plants, Moshkov . . . found that frost resistance depends on photoperiodic response, a favourable photoperiod applied for only 20 days being adequate for some species." Burkholder says : " The phenomena of abscission and leaf-fall in relation to photoperiod has been investigated by Garner and Allard in *Rhus glabra, Liriodendron tulipifera* and other plants. Several individuals of these species were grown outdoors during the summer and were transferred into the glass house in early autumn, where one lot of plants was given the light of natural day length and the other was given daylight supplemented with artificial light of low intensity in the evening. The lot of *Rhus* plants which were provided only with ordinary daylight dropped their leaves, but the other plants in long-light periods retained their dark green leaves. The *Liriodendron* trees treated with supplementary light also kept their leaves and grew new ones, while the other lot of trees abscissed their leaves and remained dormant. This type of behaviour was not characteristic of some other species of plants in the experiments. Kind has observed that in autumn the leaves of poplar, linden, chestnut, etc., situated near street lights remained green on the trees from two to three weeks longer than usual. Kramer has found that yellow poplar seedlings given supplementary electric light until midnight never became dormant but continued to grow through the winter. These observations appear to be of importance in view of the newer knowledge concerning plant growth-substances which prevent abscission of petioles."

The influence of photoperiod coincident with the effects of different temperatures on another aspect of the periodicity of perennials—the rest period—will be discussed in a later section.

The Influence of Photoperiod on Underground Organs.

The formation of bulbs, tubers and thickened roots and other underground storage organs is generally improved by a different day length from that which is favourable for vegetative growth. Most tuber-forming species show extensive top growth and limited tuber development under a long photoperiod and the reverse under a short photoperiod, when the top growth is quite limited. Thus shortening of the photoperiod below the optimum for stature or flowering in the soy bean gave tuberation. The tropical yam gave a greater size of tubers under a 12-hour day than under a longer photoperiod. The dahlia produced few thickened roots in longer days, but in the short days gave notably thickened storage roots. The onion is an exception to the general response, since

vegetative activity is increased in short days, and bulb formation promoted by long days.

As with the production of flowers, so with the development of underground parts the photoperiodic requirements of species and varieties may differ significantly. This may be exemplified by the results from some Russian experiments with different species of *Solanum*.

" In tests with regulated photoperiods, *Solanum tuberosum* was indifferent to this factor so far as concerns initiation of tuber formation, while a long photoperiod caused considerable delay of tuber formation in *S. andigenum*, and brought about complete suppression of tuberization in several other species of *Solanum* and certain tuber-forming species of *Ullucus*, *Oxalis* and *Tropæolum*. All species, without exception, showed maximum vegetative growth and usually flowered abundantly under long-day conditions, while the short day was optimum for tuber formation."

Tuberization in the potato is of special interest, since manipulation of the photoperiod enables the absolute maximum yields to be obtained. Short days produce the maximum top to yield ratio. But under such a short photoperiod the tops are small. By giving an initial exposure to long days, extensive top developments take place without tuberization. If this photoperiod is then followed by short days, intense tuberization sets in, and because of the size of the photosynthetic system the absolute maximum yields are gained. The reverse treatment, i.e. short days followed by long days, produces a small yield of tubers, which in the subsequent long days frequently revert to stolons and give rise to new shoots.

This effect is illustrative of the *photoperiodic after-effect or induction*. By this is meant the type of result obtained when plants are grown under an initial exposure to the correct photoperiod, and are later transferred to the unfavourable photoperiod.

According to Garner, when typical short-day plants were first exposed to a short photoperiod of 10-12 days, sparse and much delayed flowering occurred when the plants were transferred to long days. Some additional initial short-days were necessary to produce abundant blossoming in the subsequent long days, and 21 days of the initial favourable days were necessary for successful fruiting in the subsequent long days.

A true photoperiodic induction involves the acceleration of flowering (or that particular type of differentiation being studied), in an unfavourable photoperiod. Thus a short-day after-effect is possible only in short-day plants, and a long-day after-effect in long-day plants. A long day can produce no after-effect for a short-day plant, because it will not induce flowering or whatever is the character which is being studied.

Murneek suggests that an unfavourable day length for blossom bud differentiation produces a *photoperiodic inhibition*. Rudbeckia is a typical long-day plant. When grown in the natural day-lengths of late winter and early spring (10-13 hours) and then subjected to long days (14-18 hours), the

stem elongates naturally from the leaf rosette stage. If, instead, plants are subjected to short days of seven hours, they remain as rosettes without flowers or with sessile flowers which may appear either as normal or as " vegetative " flowers. The latter have green petals and imperfectly differentiated floral organs.

During the period of exposure to short days, it thus appears that elongation of the stem is inhibited. Under longer days (13 hours), the more advanced plants differentiated blossoms, the less advanced did not. If short days are now given, any further differentiation is prevented, but blossoms which have differentiated under the 13-hour day develop sessilely and vegetatively.

The formation of vegetative flowers is taken to indicate that a certain " dosage " of long days is necessary to induce complete floral differentiation, and also to induce the characteristic stalk development. Thus unfavourable days may be quite inhibitory in their action.

Floral Type—Sex Reversal.

In this example the flowers are an imperfect morphological transition. Photoperiod influences floral morphology and differentiation very profoundly in several plants. It will be recalled that blossom bud formation is completely inhibited in darkness. At low light intensities the pollen and ovules are produced in several plants, but are non-functional. Under a 12-hour day length, maize has been found to show complete reversal of the staminate flowers to the functional carpellate condition, so that ears develop instead of tassels. The male flowers in maize may be suppressed completely by decreasing the light period to a suitable day length. Hemp is a short-day plant in which optimum flowering is induced by a seven-hour day. Staminate hemp may undergo sex-reversal and develop carpellate flowers when grown in the short winter days of a north temperate latitude. More intersex types are formed in the winter months. The number of staminate flowers in cucumber is increased when grown in abundant light, and pistillate flowers increased under reduced light conditions.

The influence of the environment for altering the ratio of floral types in those species which may be influenced varies with the strain. Thus the monoecious form of *Ambrosia* is very stable and is reported to be affected only by an increase in photoperiod after floral buds have appeared. But other forms had the ratio of their floral types altered by a photoperiod of 20-24 hours.

The Influence of Temperature and Humidity on Photoperiodic Response.

In the natural environment, plants are subject not to the seasonal march of day length alone, but also to the seasonal temperature and humidity changes. That temperature and humidity may influence the photoperiodic response has

been shown by several experiments. In general, low temperatures slow down the rate of growth, so that when plants are grown in a fixed day length of suitable duration the length of the preflowering stage shows a close correlation with the mean temperature of exposure. By a combination of low temperatures and high humidities, the photoperiodic response of soybeans and cotton may be delayed. This combination advances the time of day length response in cosmos. The photoperiodic response of salvia or buckwheat does not seem to be influenced by variations in the temperature and humidity.

The relation of temperature to day length as affecting blossom bud formation, yield, and the onset of the rest period has been studied in the strawberry. Plants were grown under short and long days at different temperatures. Under short days, at 55° F., there was least growth and some varieties went into the rest period. At 66° F. there was heavy fruit bud formation, although fruit development was naturally slower than at 70° F. At 70° F. some varieties continued fruit bud formation, but others went into rest. With long days no fruit buds were formed, but growth increased correspondingly with the rise of temperature. The conclusions of interest to the present aspect of photoperiodism, as well as to that of the periodic growth of perennials, are the following: the rest period appeared to result from nutritive conditions caused by short days and low temperatures; the transformation of vegetative growing points to blossom required shorter daily light periods at higher temperatures than at lower temperatures; and varieties have characteristic temperature day-length responses which determine their adaptation.

There is evidence from prolonged researches at Cornell that temperature alone may control blossom differentiation in some plants. By controlling the temperature alone under which celery and cabbage were grown, the type of growth was changed at will, and by controlling both temperature and day-length the type of growth of beets and some other plants were deliberately changed. Day-length had less influence on cabbages than temperature. Thus at cool temperatures cabbages took 75 days for the growing point to emerge from the heads. These plants flowered in 150 days but produced no secondary heads. At medium temperatures, cabbages took 50 days for the growing point to emerge from the heads; the plants did not flower, but produced secondary heads. Longer days slightly hastened the time of each of these developments at each temperature used. It was concluded from these studies with celery, cabbage, beets, spinach and lettuce that as much importance attaches to temperature as to day-length.

Conclusion.

To conclude, it may be said that although some day-length effects have been described rather briefly, this treatment does not afford as general a view

of photoperiodism as is desirable. Photoperiodic effects have been established for a number of phases of plant growth and development. These include blossom bud differentiation, top to root ratios and underground organs, floral types and sex reversal, the character and extent of the branching, pubescence, pigmentation, dormancy, senescence and rejuvenation and vernalization. Some of these particular aspects have not been discussed, nor have some other aspects, such as the failure, to the present time, to arrive at quantitative aspects of light for plant response, the localization of response and the very suggestive growth-substance relationships involved in photoperiodism. These aspects could not be treated as briefly as the empirical morphological responses described in the preceding sections.

Many phases of differentiation as well as many, indeed all, physiological processes of the plant are affected by the photoperiod. Since the photoperiodic response affects the entire life activities of the plant—both physiology and the what may be regarded as " physiology made permanent " in anatomy and morphology—there is some question of the adequacy of the present system of classification—the photoperiodic classes. A more fundamental classification is being sought. Since this involves a much clearer insight into the " mechanism " of length of day, the more comprehensive view is not yet possible.

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Indices in Agricultural Climatology

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Introduction.

Most agriculturists and biologists are faced at some time or other with the necessity of comparing climatic conditions in separated localities, and of finding some suitable expression which will convey in a single formula and without undue qualification the climatic conditions of a given environment. In Australia for many years, total rainfall or seasonal rainfall was deemed to be ample for this purpose, but with the increasing interest in problems covering more than a single State, the necessity for qualifying the simple rainfall values has become insistent.

It is not only in Australia that the problem has received attention ; a recent number of the " Annales Agronomiques ", the organ of the French agricultural research stations, devotes a whole issue to the subject and contains a special contribution on first principles by Geslin (1937). The aim of a climatic formula should be to express the relative values of the rainfall at a number of widely separated localities. For many years, workers were satisfied with expressions covering the annual values, but agricultural workers, as Geslin points out, and as our experience at the Waite Institute has shown, need to take cognisance of the monthly values at least. The most important climatic normals that are available for study are rainfall, temperature and humidity ; these are to be linked in some way with soil moisture conditions before a satisfactory formula can be achieved. Rainfall and temperature are well understood and easy to express, but with respect to humidity there are a number of possible alternative methods of expression and measurement, and the interested worker may be referred to Buxton's paper (1931) for an account of methods for its measurement and control.

Humidity and Evaporation.

These alternative methods of expression are relative humidity, vapour pressure, that is, the actual amount of water vapour present in the atmosphere,

and saturation deficit, the difference between the vapour pressure of the atmosphere saturated with water vapour at a given temperature and the amount actually present. These latter quantities are expressed as centimetres or inches of mercury, or alternatively, and probably more frequently in future work, as millibars or thousandths of an atmosphere (1,000 millibars=29·53 inches of mercury). Quite frequently, however, the values are expressed as grammes of water vapour per cubic metre of air. The relationships between these quantities can readily be grasped if the march of humidity be taken for an inland station in Australia. During the early morning, temperatures are low but relative humidities are high, frequently reaching saturation ; as the day warms up the relative humidity may fall to 30 per cent., but the amount of water vapour in the atmosphere has changed very little and the vapour pressure remains constant throughout the day. It is therefore of greater significance as a climatic constant than is relative humidity. As the temperature rises, however, the amount of water vapour that would be required to saturate the atmosphere increases rapidly, and the difference between this hypothetical saturation value and the actual vapour pressure at any moment is the saturation deficiency which thus fluctuates during the day, being nil at the dew point in the early morning and rising to a maximum at the highest temperature for the day. The value of the saturation deficit is readily calculated from the temperature and the relative humidity.[1]

The rate of evaporation from a soil or from a free water surface, or of transpiration from a crop is determined by the saturation deficit. Other factors being constant, evaporation from a free water surface is proportional to the saturation deficit, a relationship emphasized as long ago as 1802 by Dalton. The amount of evaporation from a free water surface is in addition, however, a function of the barometric pressure, the absolute temperature of the air, the temperature of the water, the length down wind of the evaporimeter, the velocity of the wind, and the degree of turbulence of the wind. Graham Millar (1937) has recently shown the extremely complicated character of these relationships, and for practical purposes it is wise for the agriculturist or biologist to average these additional factors for his evaporimeter and to deal simply with the relationship between evaporation and saturation deficiency. For the 144 monthly values at a selected range of twelve Australian stations,[2] the coefficient of correlation between evaporation and saturation deficiency has been found to be 0·972, a relationship which can be conveniently expressed

[1] Tables for the conversion of temperature and relative humidity to saturation deficiency have recently been published by the Waite Institute and are available on application.

[2] These stations are : Perth, Brisbane, Sydney, Canberra, Dubbo, Eucla, Coolgardie, Merbein, Griffith, Waite Institute, Melbourne and Hobart.

for the standard Australian evaporimeter, 36 inches in diameter with a guard ring 6 inches wide, as

$$E = 21 \cdot 2 \text{ s.d. for a month of 30 days}$$

$$\text{or } E = 258 \text{ s.d. for the annual values,}$$

where E is the depth of evaporation expressed in inches, and s.d. is the saturation deficiency expressed in inches of mercury and calculated from the mean monthly maximum and minimum temperatures and the mean monthly relative humidity at 9.0 a.m. The values so obtained from these 9.0 a.m. readings have been shown (Prescott, 1934) to be very close to the actual weekly means.

Where evaporation is being measured, this acts as a convenient integrator of saturation deficit, but evaporimeters are still far from standardized. The actual depth of water evaporated depends on the size of the evaporimeter and the depth of the rim. The smaller the evaporimeter, the greater the depth of water lost. In all probability the depth of water lost from a large open reservoir is about 80 per cent. of that lost from our standard Australian tank. In addition, many observations throughout the world are made with the Piche evaporimeter, which can be suspended in the standard screen, while other observations are made with the Livingston atmometer. The Piche readings are in terms of volume, but a suitable formula is used to convert the readings to a depth of water from a free water surface.

Evaporation from the Soil and Crops.

So far as the rate of evaporation of water from a soil is concerned, it has long been known (*vide* Warington, 1900) that the rate of loss from the surface of a saturated soil, expressed as depth of water, is somewhat greater than that from a free water surface, but unless the supply of water is renewed the rate of loss quickly falls. If the surface conditions of the soil are to be maintained near the saturation point as is required, for example, for the hatching out of the eggs of certain insects, it is obvious that rainfall must at least be equal to the evaporation from a free water surface, and this forms the starting point for Davidson's work (1934) on the subject of the seasonal activity and the climatic control of the distribution of the lucerne flea.

It is profitable to examine some records enabling comparisons to be made between the water lost from a free water surface and that from a soil, either bare or under a crop. An early investigation affording data for the purpose is that of Greaves (1876), who over a period of fourteen years (1860-1873) determined the amount of water percolating through a depth of three feet of soil and through sand placed in special tanks or " Dalton gauges ", as lysimeters were then called, Dalton having constructed the first gauge for this purpose in 1796.

Other data are available from Egypt and from Australia, and they are all summarized in the following table :

Locality.	Nature of Evaporating Surface.	Ratio of the Evaporation from Soil to that from a Free Water Surface.	Source of Data.
Lee Bridge, England ..	Soil with grass cover.	0·51–1·68 (mean 1·01)	Greaves (1876).
	Bare sand.	0·08–0·40 (mean 0·22)	Greaves (1876).
Giza, Egypt ..	Irrigated cotton field.	0·42–1·40	Balls (1913).
Bahtim, Egypt ..	Irrigated maize field with moisture maintained at optimum level.	0·33–1·59	Prescott (1921).
Griffith, N.S.W. ..	Irrigated lucerne field.	0·52	West (1933).
Versailles, France	Bare soil, fully saturated.	1·67	Geslin and Servy (1937).
Adelaide, S.A. ..	Bare soil over range : field capacity to wilting point.	(*a*) For containers of similar dimensions 0·25. (*b*) Compared with standard evaporimeter 0·33.	Trumble (1937).

The lowest value for soil with grass cover (0·51) at Lee Bridge is for the month of July, which is the only month consistently without percolation. In the case of the sand, percolation was active in every month of the year.

In the case of the cotton field, the lowest value (0·42) represents conditions when the plants were still small and when evaporation from the bare soil was estimated to be nearly twice that through the crop ; the highest value (1·40) was almost entirely associated with transpiration. Similar conditions obtained in the case of the maize field at Bahtim. For the Egyptian data, the evaporation has been computed from the saturation deficiency. Greaves' data for evaporation from a free water surface agree remarkably closely with our current Australian data.

The above data give some measure of the amount of rain or irrigation that might be expected to be required to keep pace with the losses from the soil by evaporation. The amount required will depend on the state of the crop and on the texture of the soil. For normal loamy soils, the amount required would appear to be about one-quarter of the evaporation from a free water surface for fairly dry conditions and uncropped soil, to values of the order of 1·6 times for a rapidly growing crop such as maize, or for conditions where the soil is under crop but maintained moist enough to allow of free percolation. West has further shown that the amount of evaporation from a crop of well established lucerne is independent of the height of the crop.

Rain, however, does not fall continuously, and the amount that is not lost by run-off or by immediate evaporation percolates into the soil, where it is stored. On many soils an inch of water will penetrate about four inches into the dry soil, and it is desirable to know the rate of evaporation of water from a soil over the range from field capacity to, say, the wilting point. This will depend on the depth of soil considered, and will be slowest for the deeper layers. It will, in any case, take longer for an inch of rain to evaporate from the soil than it would from a free water surface. With most of the climatic studies conducted at the Waite Institute, the agricultural period and active biological period have coincided with the rainy season, and it has not been necessary to consider water stored in the soil from previous rains. With cereals and winter pastures, this is quite practicable, but it is obvious that the study of, say, the vine in the same environment will demand a study of the moisture stored in the soil and of the relationships between rainfall and evaporation from the soil in the winter months prior to the vintage season. There is in fact statistical evidence that the vintage in South Australia is affected by climatic conditions during the prior 24 months. A similar state of conditions must prevail in considering agriculture in Queensland, where the winter cereals depend to an appreciable extent on the moisture stored from the rains of the previous summer.

The solution of this problem was first attempted by Leake (1928), who allowed a progressively smaller effect for the rainfall of the several days preceding the one under consideration. It is a subject which has considerably interested the French workers, notably Chaptal (1931) and Servy (1936), who have proposed an index of dryness for any given month which similarly allows progressively less for each preceding month, taking into account the ratio of rainfall to evaporation in each of these months. The index of Servy has been successfully employed by Geslin and Servy (1937) to relate climatic conditions and soil moisture with some degree of success for the region of Paris.

Climatic Factors and Ratios.

The principal problem in agroclimatology may therefore be considered to consist of finding an expression relating rainfall to evaporation which will closely approximate to the agricultural value of the rainfall under all conditions of temperature and atmospheric humidity. There are in practice three methods of approach. The most obvious method is to subtract the evaporation from the rainfall. This has been done for the annual values for Australia by Griffith Taylor (1920), and for India by Raman and Satakopan (1935). When the values so obtained are plotted on the map, however, the areas in which rainfall exceeds the evaporation are seen to be confined to relatively small areas of very high precipitation and to exclude the agricultural areas of greatest interest.

The second method is to compare simple ratios of rainfall to evaporation or to some factor such as saturation deficit or a function of temperature related to evaporation. The use of the simple ratio of rainfall to evaporation was first suggested by Russell (1888), and of rainfall to saturation deficit by Meyer (1926), while the best known temperature relationship is that of de Martonne and Aufrère (1925). The mutual relationships of these and other indices have been discussed by Prescott (1934).

The third method of approach is that of Crowther (1930), who investigated by statistical methods the relationships between rainfall and temperature required to maintain certain specified soil conditions. Crowther's interest was in the weathering and in the leaching of the soil, and he suggested that to maintain equivalent conditions a rise in annual mean temperature of 1° C. must be compensated by an increase in the annual rainfall of 3·3 cm. Amongst other things, Crowther calculated the regression equation connecting the monthly amount of drainage from the Rothamsted lysimeters with the rainfall and the temperature. This equation suggests that to maintain drainage at a constant value month by month, an increase in temperature of 1° F. must be compensated by an increase in the monthly rainfall of 0·063 inch, a value which is of the same order as the one mentioned above. A numerical example may be used from Australian experience to illustrate the application of the principle involved. The soils on the Fitzroy in the Kimberley district of Western Australia are very similar to those along the Murray in the north-west of Victoria. The similarity extends both to light soils and to heavy soils, and it may be assumed that the leaching factors are approximately the same in each case.

The principal differences are seasonal ones. Two localities with soils of similar character are Noonkanbah and Mildura, and the meteorological normals of interest in the comparison are :

	Noonkanbah.	Mildura.
Annual rainfall	19·18 inches	10·56 inches
Seasonal rainfall	12·31 inches	5·35 inches
Length of season	2·9 months in summer	5·1 months in winter
Mean monthly seasonal rainfall	4·24 inches	1·05 inches
Mean monthly seasonal temperature ..	87° F.	54° F.

The difference in seasonal temperature of 33° F. is therefore compensated by an increase in the average monthly seasonal rainfall of 3·19 inches, corresponding to 0·097 inch for each degree. This method has not received the attention it deserves, and is likely to be even more useful if temperature can be replaced by saturation deficit.

A further example of the use of similar temperature relationships, those of Koppen (1923, 1931), is afforded by the recent analysis by Miss Lawrence (1937) of climatic conditions over a period of years in New South Wales.

The most general principle adopted, however, has been the comparison of the ratios of two quantities, one representing the amount of rainfall, the second the amount of evaporation. It is assumed that where these ratios are equal, similar climatic conditions prevail where moisture is the only consideration. This assumption is only justified, however, where the range considered is not too extreme, and there is need for the further investigation of such extreme cases. A characteristic of these ratios is that as high rainfall is usually associated with low evaporation and low rainfall with high evaporation, the ratios representing extreme conditions of humidity and aridity are unduly widely separated as to order of dimensions. There is, however, a range of values which has proved to be particularly useful in climatological studies ; this range covers the values of the monthly ratios of rainfall to saturation deficit from 5 and 35, and of rainfall to evaporation between 0·25 and 1·67. The principal advantage of the latter ratio is that both rainfall and evaporation are understood to be expressed in the same units, whereas it is always necessary to define the units employed in saturation deficiency and the period over which the ratio is measured. The disadvantages of the use of evaporation are that it is in any case a conventional figure depending on the local standard evaporimeter, and that extrapolations to stations not employing an evaporimeter are invariably based on the saturation deficit at those stations.

As examples of the employment of these ratios, reference may be made to our experience at the Waite Institute. In 1929 (Prescott and Piper, 1930) observations of soil moisture were made on a fallowed soil at twice-weekly intervals. When these records are examined in the light of the climatic conditions prevailing at the time, it is found that the surface four inches of soil was maintained above the wilting point for a period of 5·6 months during which the monthly values of the ratio of rainfall to saturation deficit exceeded a value of 5. The surface soil was maintained at the full moisture conditions for optimum biological activity for a period of 3·9 months, during which the ratio of rainfall to saturation deficiency exceeded the value 13·2. The values correspond to ratios of rainfall to evaporation of 0·24 for the wilting point, and of 0·62 for the fully wetted soil. Trumble (1937) compared the evaporation from a block of soil with that from a free water surface of the same dimensions. He determined the ratios between the water lost from the soil and that lost from a free water surface for the period during which the moisture content of the wetted soil was reduced to the wilting point. His mean value for this ratio is 0·25, which is identical for all practical purposes with that obtained from the soil moisture determinations mentioned above. He also examined the monthly values for this ratio of rainfall to standard evaporation during the recognized agricultural season over a period of years, and was

able to show that the period during which the monthly values of the ratio exceeded the value of $\frac{1}{3}$ corresponded almost exactly with the length of the season.

Davidson (1934, 1935, 1936) has used corresponding monthly ratios of $\frac{1}{2}$ and of 1 in evaluating bioclimatic conditions and in mapping bioclimatic zones. Davidson's values are based in part on soil moisture data, and in part on his observations of the behaviour of insect life. More recently, Donald and Smith (1937) have examined the climatic factors influencing the setting of seed in subterranean clover. It was found that there was a negative correlation between the number of seeds set and the standard evaporation between the 8th and 28th day after the commencement of flowering. In this case, the correlation between seed setting and the ratio of rainfall to evaporation was not found to be satisfactory.

It is evident that the combination of the meteorological monthly normals of rainfall, temperature and saturation deficiency into various indices is of considerable interest to the student of comparative climatology who is interested primarily in atmospheric or in soil moisture. It is possibly a little too early to expect the discovery of a single index which will be of universal application. For the present it appears to be the wisest plan to examine each problem of bioclimatology or agroclimatology on its own merits, and to determine the most suitable index to meet each particular need as it arises.

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TECHNICAL NOTES

RESPONSE TO COPPER ON A SOUTH AUSTRALIAN SOIL.

Along the south-eastern coast of South Australia lies a strip of blown calcareous sand, some hundreds of miles in extent. It is formed of dunes of Recent age, and is remarkable for its high content of calcium carbonate—over 60 per cent. in the surface soil and increasing with depth. It has a pH of 8·5 at the surface increasing to 9·2 at depth. Sheep grazing in this area suffer from " coast disease ".

Natural pastures are poor and consist almost entirely of inferior annual grasses. Rye is the only cereal which can be successfully grown either as a hay or grain crop. Wheat, oats and barley show general lack of growth and develop severe disease symptoms. The leaves droop ; and there is considerable withering, curling and death of the tips. Should the heading stage be reached, grain is rarely formed.

The application of copper sulphate has led to normal vegetative development and markedly improved grain production. The disease is identical with " reclamation disease " (*Urbarmachungskrankheit*) of north-western Europe.

A wide range of pasture species was sown, but the majority of them failed to develop beyond seedling size. The application of copper sulphate at 28 lb. per acre, though in some cases giving slight visible response, did not prevent their general failure. Nevertheless, under pot culture conditions, an apparently normal development of subterranean clover was secured by copper sulphate applied at an equivalent rate.

Indications have been obtained that other minor elements may be deficient in this soil, or unavailable to plants. An account of preliminary investigations will appear as a pamphlet of the Council for Scientific and Industrial Research.

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OCCURRENCE OF *BACTERIUM SYRINGÆ* (VAN HALL) E. F. SMITH ON FRENCH BEANS (*PHASEOLUS VULGARIS* L.) IN NEW SOUTH WALES.

In March, 1936, isolations made from French bean leaves collected from several crops in the Baulkham Hills district and from one crop in the Mudgee district yielded an organism closely resembling *Bacterium syringæ* (Van Hall) E. F. Smith. In October, November and December, 1937, an organism, apparently identical with that isolated in March, 1936, was secured from bean

French Bean Leaves showing Bacterial Infection.
At left : Caused by *Bacterium syringæ.*
At right : Caused by *Bacterium medicaginis* var. *phaseolicola.*

leaves from crops in the Dundas, Richmond, Baulkham Hills and Mudgee districts.

As far as the writer is aware, there are only two previous records of the natural occurrence of *Bact. syringæ* or its synonyms on *Phaseolus vulgaris.* In 1930, Burkholder[2] recorded the occurrence of *Phytomonas* (*Bacterium*) *vignæ* var. *leguminophila* Burkholder on bean plants in New Jersey. In 1935, the same organism was reported as having been isolated from bean seed in England.[1] Clara[3] in 1934 concluded that *Phytomonas* (*Bacterium*) *vignæ* var. *leguminophila* could more correctly be designated *Phytomonas* (*Bacterium*) *syringæ.*

Affected leaves showed reddish brown lesions with very little yellowing of the surrounding leaf tissue. The symptoms could not be confused with the

typical "halo" spot produced by *Bacterium medicaginis* var. *phaseolicola* (Burkholder) Link and Hull, but it would not always be possible to distinguish between the two diseases under dry weather conditions. Pods affected with this disease have been observed in the field in only one crop. The lesions were brown, slightly sunken and somewhat less than five millimetres in diameter. They were very similar to the type of lesion obtained by needle puncture inoculation of pods with pure cultures of *Bact. syringæ*. Stem lesions have not been observed in the field.

All of the isolates have made a somewhat abundant white growth on beef-extract peptone agar slopes, have produced a brown, sunken, necrotic lesion when inoculated with needle prick into pods of the French bean, and have been pathogenic when inoculated by needle puncture into the stems of young French bean, cowpea (*Vigna sinensis* (L.) Endl.) and snake bean (*Vigna sesquipedalis* Wight) seedlings. When young bean seedlings of the varieties Tweed Wonder and Red Kidney were inoculated with any of the isolates by needle puncture of the stem at the cotyledon node, the plants showed signs of wilting and usually collapsed above the point of inoculation within two to four days. Cultures obtained by reisolation from inoculated plants proved to be identical with the cultures originally isolated from French bean leaves.

Cultural, biochemical and physiological characteristics of some of the isolates were determined, and were found to be in general agreement with those of other strains of *Bact. syringæ* as reported by Clara[3] and the writer.[4] The characteristics investigated included size of cells, motility, flagellation, gram stain reaction, type of growth on beef-extract peptone agar, potato dextrose agar and in beef-extract peptone broth, and the action on milk, litmus milk, gelatin, nitrate, 12 sugars and alcohols, and five organic acids. All of the French bean isolates which were studied fermented raffinose as rapidly as did certain cultures of *Bact. syringæ* from citrus.[4]

Whilst this disease has been recorded in New South Wales for only a few localities, it is not improbable that its distribution is very much wider than the records indicate. However, observations suggest that this disease is unlikely to become of such economic importance as the disease caused by *Bact. medicaginis* var. *phaseolicola*, and that the latter disease remains as the most important bacterial disease of French beans in this country.

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ROUTINE DETERMINATION OF LIPOLYTIC ORGANISMS IN BUTTER.

The development of tests for the detection of lipolytic organisms has raised the question of the need for incorporating such a test in the routine examination of butters as performed by this laboratory, and the following work was undertaken to ascertain the suitability and efficiency of Nile Blue Sulphate Beef Infusion Agar, one of the many methods outlined in contemporary literature.

Organisms producing rancidity in experimental butter and giving a positive Nile Blue test were demonstrated. The results were confirmed by both Eijkman's[1] and Berry's[2] methods. Commercial butters very often gave a positive Nile Blue test, but in no case did such butters develop any sign of rancidity during the routine keeping-quality test, or was there any apparent correlation between the number of lipolytic organisms present and the class of the butter. Although experimental butters were plated in dilutions 1/10,000 and 1/100,000 on Nile Blue, there were always more than 500,000 lipolytic organisms present per ml., whereas all butters containing a total number of organisms exceeding 25,000 per ml. were regarded as C class. The test is admirably suited to laboratory procedure, but the additional information gained does not warrant including it as a routine test.

In the development of rancidity, hydrolysis of butter-fat to glycerol and free fatty acids is an initial stage only, as the real flavour and aroma of rancidity are due to subsequent oxidative changes of either the fatty acid or glycerol so liberated.[3] [4] Such changes as those, yielding epihydrinaldehyde, other aldehydes, ketones and lower fatty acids, even in minute amounts, have a marked effect on flavour and aroma. Pure butter-fat (i.e. containing no traces of protein, salt, or water) has been known to keep for twelve months without developing rancidity.[5] Probably the presence of curd, salt, metallic contamination, and degree of working are contributory causes to the development of rancidity, and supplementary to the activity of microorganisms.

Hussong's[6] modification of Turner's[7] original method was used in the preparation of the Nile Blue plating media used in this investigation. This medium depends for its action on the liberation of free fatty acids by the activity of microorganisms capable of splitting fats. In interpreting the results, only colonies producing a haze of blue dots were regarded as positive. These results were confirmed by Eijkman's and also by Berry's methods on eight separate occasions. Both these methods indicate the degree of change which has occurred, whereas Nile Blue indicates positive or negative reaction only. The degree of change so indicated was later found to follow exactly the intensity of rancidity as detected in experimental butters. Turner's Bile-Fat-Agar[8] was tried and found unsuitable owing to the high degree of sensitivity to bile of the organisms concerned. Buchanan's method[9] was tried also and found to be rather indistinct. The methods of Berry and

of Eijkman were found to give clear results, especially Berry's method. They completely verified the findings of the Nile Blue method. The Nile Blue method was found to be more readily applicable to the routine examination of commercial butters than any of the other tests examined.

Experimental.

Sterile samples of experimental butter were churned in sterile glass jars from cream, laboratory pasteurised at a temperature of not less than 185° F. (actual cream temperature) for fifteen minutes. The butters were washed with sterile water, and after working in a sterile manner were inoculated with the desired culture and wrapped in sterile paper. The samples were unsalted and made from cream neutralised to 0·1% or having an original acidity of less than 0·1%. The experimental butters were examined at periods not greater than twenty-four hours (and more frequently when necessary). In no case did the control samples show any tendency to develop rancidity. As soon as rancidity was detected in an experimental butter it was plated on Nile Blue in dilutions 1/10,000, and 1/100,000 and in all cases there were present more than 500,000 colonies per ml. positive to Nile Blue. The controls were plated on Lactose Agar[10] and no control showed the presence of any organisms per ml. Lactose Agar was used as Nile Blue has an inhibiting effect on the growth of microorganisms. The plates of rancid butters were carefully examined and twelve macroscopically dissimilar colonies picked off. Each was emulsified in sterile water on a microscope slide, and inoculated into experimental butter, inoculated into milk, and the remaining smear stained by Gram's method. These twelve butters were examined after forty-eight hours by two certificated graders, and five were declared rancid, three "rabbito", one cheesy, while three had an indefinite off-flavour (two of the latter subsequently developed rancidity). The control was considered to be quite clean.

The rancid butter cultures were used as a nucleus for a new series which also included three cultures negative to Nile Blue, and a recent isolation from a commercial butter (No. 259). This series was inoculated into experimental butters, and also tested for ability to split fats by the methods of Berry, Eijkman, and Nile Blue. Rancidity developed within two days in the butters inoculated with positive cultures. These butters were plated in a dilution of 1/100,000 as soon as the defect was detected. The whole series was plated in a dilution of 1/1,000,000 eight days after inoculation. In all cases, the counts were in the vicinity of 50,000,000 colonies per ml. Only butters detected as rancid showed colonies positive to Nile Blue, and these results were closely verified by Berry's and Eijkman's methods. The organisms producing rancidity were uniformly Gram negative, and predominantly cocco-bacillary. No. 259 was a pure cocco-bacillary culture, but an occasional

bacillus was detected in the other rancidity producing cultures. Stark and Scheib[11] found Gram-positive rods, and Collins and Hammer[12] found both Gram-positive and Gram-negative rods producing rancidity. Gelatine stab cultures were made of the series, and those producing rancidity were found to be very active liquefiers. All these formed a conical zone of liquefaction along the line of stab with a light buff sediment, and some formed a pellicle. Of the forty-two commercial butters collected on Melbourne grading floors and examined by Nile Blue, 86% showed the presence of colonies positive to Nile Blue. However, none of these developed rancidity during the keeping quality test (aroma after melting at 42° C. and holding at room temperature, 15° C., for two days).

It is therefore considered that the test should be used only in special circumstances, as, whatever the type, large numbers of bacteria, as indicated by the usual routine media, are indicative of the need of more vigorous cleansing and sterilization in manufacture and handling of butter.

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A SELECTIVE MEDIUM FOR *BACTERIUM MEDICAGINIS* VAR. *PHASEOLICOLA* (BURKHOLDER) LINK AND HULL.*

During investigations of the bacterial disease of beans caused by *Bacterium medicaginis* var. *phaseolicola* (Burkholder) Link and Hull, attention was directed to the possibility of evolving a selective medium which could be utilized in the detection of seed infection, as well as in the isolation of the organism from soil and other sources where numerous other microorganisms might be found in association with the pathogen.

Selective and differential media have not been used to any great extent for the bacterial plant pathogens. Patel[3] has described one such medium for *Bacterium tumefaciens* Smith and Townsend, whilst Ivanoff[2] has described one for *Aplanobacter stewarti* (E. F. Smith) McCulloch.

In the development of a selective medium for *Bact. medicaginis* var. *phaseolicola*, an investigation was first made of the nitrogen and carbon sources which could be utilized by the organism. It was found that the organism could utilize nitrates, as well as ammonium salts, as its source of nitrogen. However, the growth on synthetic media in which nitrates or ammonium salts were used as sources of nitrogen was very poor in comparison with the growth obtained with standard beef-extract peptone broth or agar. The addition of very small quantities of potato and bean extract to synthetic nitrate media was found to stimulate growth. The work of Clara[1] in reference to the utilization of various carbohydrates and alcohols was confirmed. Of the carbon compounds utilized by *Bact. medicaginis* var. *phaseolicola*, glycerol appeared to be the best for use in a selective medium.

Growth in Presence of Inhibitory Substances.

The ability of the organism to grow in the presence of substances inhibiting the growth of other microorganisms was determined. Various concentrations of gentian violet, methylene blue, acid fuchsin, basic fuchsin, safranin, copper sulphate, sodium taurocholate, sodium chloride, magnesium chloride, ammonium phosphate, calcium chloride and potassium nitrate were used in the following liquid media :

(i) Beef extract peptone broth ; (ii) a synthetic liquid medium containing monobasic ammonium phosphate as the source of nitrogen, and dextrose as the carbon source ; and (iii) a synthetic liquid medium containing monobasic ammonium phosphate as the nitrogen source, and glycerol as the carbon source.

* The author desires to acknowledge helpful suggestions and advice given by Dr. A. J. Riker and Dr. S. S. Ivanoff of the University of Wisconsin throughout the course of these investigations, which were carried out during the author's tenure of the Walter and Eliza Hall Agriculture Research Fellowship of the University of Sydney.

In the case of those substances inhibiting growth, it was found that this inhibiting effect was very much greater in the synthetic media than in the beef-extract peptone broth. It was noted that the addition of sodium taurocholate, except at very high concentrations, increased the amount of growth.

The possibility of utilizing sodium taurocholate, a substance inhibiting the growth of many microorganisms, for the growth of *Bact. medicaginis* var. *phaseolicola* was investigated. It was found that 1·5% of sodium taurocholate in distilled water produced a better growth than liquid media in which the nitrogen source was a nitrate or an ammonium salt, with glycerol or dextrose as the carbon source. The addition of one to five per cent. of glycerol to the sodium taurocholate medium greatly increased the growth of the bacterial blight organism.

The ability of the organism to grow in relatively high concentrations of gentian or crystal violet (as high as 1 in 2,500) suggested that either of these dyes could be employed in any selective medium which might be developed.

After further work, a medium of the following composition was finally chosen as a selective medium for *Bact. medicaginis* var. *phaseolicola* : Sodium taurocholate 15 gm., glycerol 30 gm., ammonium nitrate 10 gm., water 1,000 ml., gentian violet 0·02 to 0·2 gm., agar (for a solid medium) 15 to 17 gm. Whilst a concentration of 1 in 5,000 gentian or crystal violet was found satisfactory for a liquid medium, a concentration of 1 in 50,000 was more satisfactory for a solid medium. A concentration of the dye greater than 1 in 50,000 rendered a solid medium somewhat too opaque, and did not greatly increase the selective properties of the medium.

This preparation was compared with two other selective media for bacterial plant pathogens, namely Patel's medium for *Bacterium tumefaciens* and Ivanoff's medium for *Aplanobacter stewarti*, in its inhibiting effect on several saprophytic soil bacteria. It was found to be considerably more selective than Patel's medium but not as selective as Ivanoff's preparation.

Use in Detection of Seed Infection.

Experiments were carried out with solid and liquid selective media for the detection of seed infection. The following method was finally evolved : The seeds are placed in tubes or flasks of the liquid selective medium kept at about 25° C. After two days a loopful is transferred from each flask or tube with a sterile needle to tubes of beef-extract peptone broth. After a further two days inoculations are made from those broth tubes showing turbidity into pieces of fresh bean pods placed in petri dishes. Pod infection within two to five days indicates infection of the seed with *Bact. medicaginis* var. *phaseolicola*. If inoculations are made directly from the selective medium into bean pods, the sodinm taurocholate in the medium produces a necrosis of the bean pod tissue, preventing manifestation of infection caused by *Bact. medicaginis* var. *phaseolicola*. Consequently, it was found necessary to make transfers from

the selective medium to the beef-extract peptone broth before making the pod inoculations. Certain bacterial saprophytes carried with the seed can grow in the selective medium and, by competition with the bacterial blight organism in both the selective medium and the broth, may prevent infection when the pod inoculations are made.

It has been found that this method will detect seed infection where the direct inoculation of 6- to 24-hour-old water infusions of bean seeds into pods[4] fails to do so. However, very light seed infection is not always detected by this method.

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HIDE BEETLE DAMAGE TO OREGON PINE.

Oregon pine, *Pseudotsuga taxifolia*, is usually free from borers in Queensland. Recently, structural instability due to insect attack was investigated at the request of a fertilizer manufacturing mill-owner, and the responsible insect proved to be the hide beetle, *Dermestes vulpinus* Fabr.

This insect normally attacks hides, skins, etc., and is found commonly about stores handling these articles, and also about meatworks and fertilizer works.

Supplies of infested bones and meatworks offal are continually being received at the fertilizer mill, where breeding continues. However, as the material is more or less on the move, many of the full grown larvæ forsake it in search of a more suitable site for pupation. In their wanderings, they crawl up the posts, 24 and 36 feet high, and so reach the Oregon pine rafters, into which they burrow. Entrance is gained through the soft early (spring) wood,[1] and damage is restricted to it.

The number of external holes is not a true indication of the internal damage to the timber. One larva bores into the wood, others enter by the same hole, and the internal tunnelling then spreads out in a fan-like fashion. A single larva bores for only an inch or so, but later other larvæ continue the tunnel. Eventually the layers of early wood are so damaged that the timber assumes a laminated structure, allowing the hard layers of late (autumn) wood[2] to be easily stripped off. In regions of severe damage the remaining strength of the timber is the aggregate of that of the laminæ of late wood.

[1] The less dense larger-celled and first formed part of a growth ring.
[2] The denser, small-celled and later formed part of a growth ring.

This type of attack was confined to the Oregon pine in the building, and can be attributed to the fact that the early wood is soft enough for the larvæ to penetrate and obtain the necessary shelter for pupation. However, another site chosen by the larvæ for pupation was the outer quarter of an inch of a severely charred piece of 6 in. × 4 in. hoop pine, resting in the bracket supports of the rafters ; otherwise, this timber was free from infestation.

Oregon Pine showing tunnelling by Dermestes vulpinus.

The Dermestes larvæ and pupæ in the timber were being attacked by the predatory Clerid *Necrobia rufipes* DeG.

This is not the first record of *Dermestes vulpinus* boring into wood. A few years ago large numbers of adult beetles were found penetrating the walls of a hoop pine cupboard. A search in the cupboard revealed some forgotten skins in which the insects were breeding, and the beetles were boring through the wood in order to escape.

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The Australian Institute of Agricultural Science

EXECUTIVE COMMITTEE.

The Executive Committee reports that the final copy of the Memorandum and Articles of Association was recently circulated to all Branches of the Institute. The papers left Melbourne on November 17, 1937, and returned there on February 14, 1938, having been signed by the Branch presidents or their deputies.

Only two minor alterations have been made as a result of final submissions by the Branches. These provide for single voting by members of Council in the election of Honorary Members, and for the installation of the incoming President of the Institute at the conclusion of the regular general meeting.

The papers are at present with the Victorian Crown Solicitor for final approval. This does not mean that the Institute is committed to immediate incorporation, but that the Articles will be in proper form for such action without further amendment. The papers will be printed and should be in the hands of members for their decision by postal ballot some time this month (March).

At the Executive Committee meeting on February 16 the Honorary General Treasurer presented, subject to audit, the financial statement for 1937. This read as follows:

INCOME.		£ s. d.	EXPENDITURE.	£ s. d.
Cash at Bank, 1/1/37 ..		214 18 10	Branch Grants for 1936 ..	85 16 0
Subscriptions Received for 1937	£284 0 6		Journal Activities	180 15 6
Arrears, 1936	103 0 9		Administrative and General Expenses	66 18 3
		387 1 3	Transfer to Fixed Deposit ..	100 0 0
			Cash at Bank, 31/12/37 ..	168 10 4
		£602 0 1		£602 0 1

The Treasurer estimated that an amount of approximately £50 had yet to be received in subscriptions for 1937.

The Executive Committee decided to recommend to the Council that the *per capita* grants to the Branches in respect of the year 1937 be at the rate of five shillings and sixpence per financial corporate member at December 31.

It is hoped to publish the audited statement of accounts in the June issue of the Journal.

NEW SOUTH WALES BRANCH.

The annual meeting of the Branch was held at Science House, Sydney, on February 11, the President (Mr. G. de V. Davis) occupying the chair. The Secretary pointed out that during the year 1937 five new corporate members were admitted to membership and one member was transferred from Victoria, bringing the membership of the Branch to 89 corporate members and one student member. The credit balance for the year ending December 31, 1937, was £12 3s. 7d.

Election of office-bearers for 1938 resulted as follows : President, Dr. J. G. Churchward ; Vice-President, Mr. G. de V. Davis ; Secretary, Mr. H. Parry Brown ; Treasurer, Mr. A. W. S. Moodie ; Committee, Messrs. L. S. Cayzer and E. G. Pont.

The presidential address, " Agriculture and a National Policy ", was then delivered by Mr. Davis. A summary of this address is published elsewhere in this issue.

QUEENSLAND BRANCH.

The November (1937) meeting of the Branch was devoted to a lecture by Professor H. R. Seddon on " Environment and Animal Health ". Though environmental influences seldom act alone, the several constituent factors were considered individually in relation to a wide range of stock diseases common in eastern Australia.

Some such as worm nodule disease are localized, possibly by the climatic restrictions on the distribution of the vector ; others, such as actinomycosis, furnish distinctive symptoms in various countries of what is essentially the same disease. Climate, through its components, temperature, humidity, wind, etc., requires very careful analysis if its total effect on animal health is to be understood. Such an analysis is very necessary if pastoral policy in relation to land settlement is to be sound. Infertility in sheep, a common phenomenon in some parts of the State, may be directly attributable to the effect of heat on sperm vitality. Climate also plays a part in determining both the type of sheep and the quality of the wool grown in some inland districts. Indirectly, climate is responsible for the development of animal poisons, e.g. cyanogenetic glucosides in the vegetation.

Other constituents in the domestic animal environment were examined in detail by the speaker, and finally the effect of economic considerations were discussed in so far as they prevent or assist the stock owner to provide the necessary shelter, fodder and watering facilities, without which production levels fall in sympathy with the decline in the animals' health. The discussions brought out a fund of personal observations on stock abnormalities in several parts of the State.

WESTERN AUSTRALIAN BRANCH.

At the December (1937) meeting of the Branch, Professor J. E. Nichols presented a paper on behalf of Mr. G. F. Melville, entitled " Some Features of the Pastoral Areas of Western Australia ".

From the aspect of utilization for sheep, the pastoral areas can be considered in two broad divisions :

(1) The top feed areas, and

(2) areas in which the vegetative plane is readily accessible to the sheep (e.g the spinifex grass regions).

The former correspond roughly to the areas of less than 10-inch annual rainfall, are of low carrying capacity although in good seasons an abundant growth of ground feed occurs. This division can be further subdivided into :

(*a*) The South Murchison scrub.

(*b*) The Mulga country of the Central and Eastern Murchison.

(*c*) The sandhill scrub of the Carnarvon region.

(*d*) The Acacia scrub of the Upper Gascoyne.

The spinifex grass country extends from the Tropic of Capricorn northwards, and is generally of higher carrying capacity. Spinifex is dominant in two main habitats :

(*a*) Sandy spinifex plains and " downs ", e.g. in the Lower Gascoyne and on the granitic areas between Ballaballa, Port Hedland and Wallal, and also associated with the calcareous coastal downs from Cape Cuvier to some 20 or 30 miles N.E. of Onslow.

(*b*) The rough hilly country including the Roebourne tableland and the broken Nullagine plateau.

A distinctive type of country occurs in the grass plains on the coastal belt between Peedamullah Station (N.E. of Onslow) and Ballaballa (between Roebourne and Port Hedland).

Pastoral conditions and problems occurring in each division were discussed, particularly in relation to the alleviation of fluctuations in pastoral production.

Current Notes and News

Professor A. E. V. Richardson's New Appointment.

It was announced immediately prior to the Christmas interval that Professor A. E. V. Richardson would resign his dual position of Director of the Waite Agricultural Research Institute and Waite Professor of Agriculture to accept the appointment of Deputy Chief Executive Officer of the C.S.I.R. At Professor Richardson's request, his official responsibilities with the University of Adelaide terminated at the end of February. The Council of the University has asked Professor Richardson to act in the capacity of honorary consultant in matters pertaining to the Waite Institute.

The news of the appointment was received at the Waite Institute with very mixed feelings. Predominantly there was a note of deep regret that he should be severing a leadership that had been so conspicuously successful in the development of the Waite Institute over a comparatively short period. At the same time, the circumstances that led to the appointment were readily appreciated. Professor Richardson was a member of the Executive of the original Commonwealth Institute of Science and Industry in 1919, and has been associated with its successor, the present C.S.I.R., since 1927. As a member of the Executive of the C.S.I.R. and synchronously as Director of the Waite Institute Professor Richardson has been able to effect a strong liaison between the two organizations in South Australia ; at the Waite Institute, it is only by a momentary check to one's thoughts that it is possible to determine who actually are C.S.I.R. officers and who are university staff.

There are few people who realize the amount of work and organization that Professor Richardson has contributed to the development of the C.S.I.R., in addition to his leadership of the Waite Institute, in recent years. With increasing evidence of the value of the C.S.I.R. to primary industry in Australia, and the expansion of its organization to include new lines of investigation, it had become apparent that the direction of those activities associated with primary industry alone was now a full-time occupation for one of outstanding ability. The recent extension of the C.S.I.R. to include a highly comprehensive programme of research in problems of secondary industry, resulting as it has in a heavy demand for Sir David Rivett's services in this direction, has proved an ultimate factor in rendering Professor Richardson's appointment a necessity. Viewed from the Commonwealth aspect, the move should be of considerable value to Australia as a whole.

It may be of interest to record that among his many activities prior to the appointment to the University of Adelaide in 1924, Professor Richardson was Assistant Director of Agriculture in South Australia 1908-10 and Acting Director 1911, Superintendent of Agriculture for Victoria 1911-24, Director of the School of Argiculture, University of Melbourne, 1919-24, President of the Section of Agriculture of the A.N.Z.A.A.S. at Wellington, N.Z., in 1923. Professor Richardson was awarded the degree of D.Sc.,

Melbourne, in 1924. He was the first President of the Australian Institute of Agricultural Science 1935-36, and was President of the S.A. Branch for 1937. He has been a member of the Advisory Board of Agriculture of South Australia since 1925, a member of the Governing Council of Roseworthy Agricultural College since 1932 and honorary member of the Czecho-Slovakian Academy of Agriculture since 1932.

Professor Richardson has travelled extensively in Australia and has carried out several missions abroad. In 1918 he enquired into agricultural education and research in America on behalf of the Victorian Government, and as a result of his recommendations the School of Agriculture was subsequently established at the University of Melbourne. In 1926 he visited Europe, South Africa, the U.S.A. and Canada, Japan, China and Java. Professor Richardson represented Australia at the Imperial Conference at London in 1927, and was official Agricultural Adviser to the Australian delegation to the Ottawa Conference in 1932.

Professor J. A. Prescott—Director of the Waite Institute.

The general reaction to the announcement of Professor Richardson's appointment to the C.S.I.R. was a feeling of satisfaction in the knowledge that Professor J. A. Prescott would be available to direct the Waite Institute. To Professor Prescott is largely due the high standard of technical equipment at the Waite Institute, and to a considerable degree the prestige of the Institute in regard to fundamental research. There are few workers at the Institute who have not benefited at some time from his wide knowledge and experience of scientific investigation, which extends far beyond his original subject, chemistry.

Professor Prescott is a native of Lancashire, but received his primary education in France. He graduated at Manchester University with first class honours in chemistry, and gained post-graduate experience in Manchester, at the Rothamsted Experimental Station with Sir John Russell and at the University of Leipzig with Dr. Wolfgang Ostwald. In 1916 he was appointed Chief Chemist to the Royal Agricultural Society of Egypt and Superintendent of Field Experiments at the Society's experimental farm at Bahtim. In addition to his work on the chemistry of soils and agricultural products, he carried out extensive researches in connection with the cultivation of cotton, maize and wheat.

With the establishment of the Waite Agricultural Research Institute in 1924, two professorships were created, one in agriculture and one in agricultural chemistry. Professor Prescott was appointed Waite Professor of Agricultural Chemistry, and on several occasions he has been acting director of the Institute.

In 1926 he was invited by the C.S.I.R. to enquire into the nature of the problems associated with irrigation in the Murray River settlements. From this developed the C.S.I.R. Division of Soils, which was established in 1929.

Professor Prescott's work in Australia has related chiefly to the classification and geographical distribution of soils, with particular reference to climatic factors. His well known bulletin of the C.S.I.R., " The Soils of Australia in Relation to Vegetation and Climate ", has become a standard reference book in high schools and universities throughout Australia. He was awarded the degree of D.Sc. at Adelaide in 1932.

Professor Prescott has travelled widely, and is personally familiar with agricultural research organizations in Sweden, France and Russia. He is also familiar with agricultural and pastoral conditions in all the States, in the Northern Territory and in New Zealand, and has shown a remarkable adaptation to Australian conditions and to Australian points of view. He is a member of the general committee of the International Society of Soil Science, Vice-President of the International Commission for the classification and cartography of soils, and was President of the Royal Society of South Australia in 1932-33,

Federal President of the Australian Chemical Institute in 1936-37 and President of the Agricultural Section at the Auckland meeting of the A.N.Z.A.A.S. in 1937. He was President of the S.A. Branch of the Australian Institute of Agricultural Science in 1936.

Visit of Dr. John Hammond.

Dr. John Hammond, of the School of Agriculture, Cambridge, and noted for his contributions to animal problems, is visiting Australia and New Zealand. His tour of this part of the world is being financed jointly by the Commonwealth and Dominion Governments, while the visit to Australia in particular has been arranged by the C.S.I.R. in cooperation with the State Departments of Agriculture and producer organizations. Members of the Institute will welcome the opportunity of hearing addresses from this distinguished scientist.

Dr. Hammond will address one public meeting in each State, and the invitations for Institute members will be sent to the respective branch secretaries. The details of Dr. Hammond's projected movements are as follow:

New South Wales: 10th-15th March, 26th March-3rd April.
Queensland: 16th-25th March.
Victoria: 4th-15th April, 21st-25th April.
Tasmania: 16th-20th April.
South Australia: 26th April-2nd May.
Western Australia: 4th-10th May.

Progress at Roseworthy Agricultural College, S.A.

The current number of "The Student", the magazine of Roseworthy College, shows abundant evidence of the progress made at that institution in recent years. Of particular importance is the development of the special course of training in œnology, in connection with which a new wine-making and distillery plant has been erected, and chemical and microbiological laboratories equipped. Mr. A. R. Hickinbotham, B.Sc., B.Ed., Dip.Ed., A.A.C.I., is in charge of the chemical, and Mr. J. C. M. Fornachon, B.Agr.Sc., of the microbiological portions of the course. Mr. F. H. Hooper, B.Agr.Sc., a recent graduate of Adelaide, has been appointed Assistant Horticulturalist. In 1937 six first year students and four second year students took advantage of the opportunities which the course in œnology offers. A further important step forward is an amendment to the Graduates' Land Settlement Act to assure holders of the Diploma in Agriculture of financial assistance for the purpose of acquiring land for settlement. Six properties were acquired under the Act prior to the annual speech day in 1937, and at that time five others were also under consideration. The large numbers of farmers and other visitors who have attended field days at the College in recent years have been a feature of its activities.

Issue of News Circular, Waite Institute.

Under the ægis of the Agricultural Sciences Club, arrangements were made towards the end of 1937 for the preparation of a monthly news circular, to be issued to members of the Club. The objectives of the circular are to keep members better informed of current activities at the Waite Institute, now that the staff has grown to its present size. The material is prepared by Mr. C. S. Piper, M.Sc., in conjunction with the Clerical Officer of the Institute, Mr. G. L. Gooden, and covers such items as new appointments, staff activities, visitors, notes of general interest, field experiment notes, notices of meetings and recent additions to the library. The circular is issued on the fifteenth of each month, the first appearing on November 15, 1937.

Developments in Western Australia.

The committee of the Western Australian Branch of the A.I.A.S. has been fortunate in securing the very active assistance of various Government Departments in connection with the land utilization survey. The work in the pastoral areas is well in hand in the Department of Lands and Surveys, and information concerning about 200,000,000 acres has been mapped. In the agricultural areas, arrangements are being made for officers of the Agricultural Bank to map information available in their files which will cover about 80 per cent. of the farming land.

As a result of a grant from the trustees of the Wheat Pool of Western Australia, supplemented from the Commonwealth grant to universities, work has been commenced in the University of Western Australia on investigations in the field of agricultural economics. The first project selected is the economics of power farming in the wheat belt, and Mr. R. P. Roberts has been loaned to the University by the State Department of Agriculture for a period of twelve months to undertake the studies. The investigation will entail a survey of a number of farms in selected districts in the wheat belt. Information will be collected with a view to establishing the principles which make for successful tractor operations under local conditions. An endeavour also will be made to assess the relative merits of different types of tractors, and of tractors as compared with horses.

Book Reviews

BACTERIOLOGY—A TEXT BOOK OF MICROORGANISMS, by F. W. Tanner, Ph.D.

(Third Edition. Pp. xiii+510, with 151 figures and 2 plates. London: Chapman and Hall. Price, 17/6.)

In this book, Dr. Tanner treats most of the more important branches of bacteriology, including general, industrial, medical and plant pathological bacteriology. There are also chapters on yeasts, moulds and protozoa.

Altogether the book contains 33 chapters, which total 461 pages of text. The numerous aspects of the subject treated have naturally forced the discussion of theories or any amplification of stated facts to be reduced to a minimum. While, in this regard, Dr. Tanner has not overcome the universal defect of text books, it is surprising what a considerable amount of detail he has found it possible to include.

A list of references at the end of each chapter will simplify the task of any student wishing to pursue further studies into any particular matter. These references are supplemented, in the Appendix, by a very full list of text books, abstract journals and journals devoted to original articles. One notable omission is the *Journal of Dairy Research*.

A feature of the book is the excellence of most of the illustrations. A careful selection of figures and photographs from other publications has been supplemented by much original material. Together with the glossary of almost 400 words, the illustrations should elucidate anything obscure encountered in the text.

Though written from the American viewpoint, the great bulk of the information in the book is equally applicable to Australian conditions. One exception to this is in the paragraph on the bacteriology of butter. Here it is stated that fresh butter may contain as many as 50,000,000 bacteria per gramme. Butter made from cream which has been acidified, " neutralised " and pasteurised is not mentioned. Also the sentence: " The

bacterial content of the finished butter is of little consequence so long as the bacteria are non-pathogenic " is misleading.

Dr. Tanner states that " this book is planned for those studying bacteriology for the first time ". But it is equally certain to be utilized by teachers. It is unlike the majority of texts, which merely list consecutive facts. In these pages, wherever a sentence of an explanatory nature is necessary, it is inserted. In this regard Dr. Tanner exhibits a keen judgment suggestive of his long experience as a teacher. The free use of definitions throughout the text is another feature which will be appreciated by student and teacher alike.

The book fulfils, with distinction, its purpose as an introductory, though not elementary, text book of microorganisms. It maintains the excellent standard which Dr. Tanner has set in his other bacteriological publications.

W. S. SUTTON.

MOTHER EARTH—LETTERS ON SOIL, by G. W. Robinson, D.Sc.

(Pp. vii+202, with 1 plate, 2 maps and 6 figures. London : Thomas Murby & Co., 1937. Price (London), 5/6.)

An excellent text book by this author on the origin, constitution and classification of soils has been published in recent years, but in this book he has chosen an unusual literary device, in the form of a series of letters to an agrostologist friend, each dealing with a branch of pedology. These letters are in effect a series of essays on the soil, viewed from the philosophical standpoint. They do not cover the whole subject comprehensively, and they never descend into technicalities. The book is not claimed to be a concise manual of soil improvements, nor even an elementary text book of pedology. The discussion is informal, and not without a note of humour. Rather than waste words inquiring into the agricultural possibilities of the coastal sands of Britain, the author simply remarks " that Providence has designed them for golf links ".

The discussions on land utilization have a distinctly local colour, being concerned with the arable, grasslands and waste lands of Wales. Much of the argument can, however, be transposed to agricultural practice in humid Australia.

Dr. Robinson sees greater possibilities in the reconditioning and improvement of the neglected farm lands of Britain than in the assault on waste lands. He deplores the extent of too-acid soils, and advocates a national liming conscience. He draws a parallel between the decay of agriculture in the Roman Empire and modern Britain.

The first principle which his studies have taught is that fertile agricultural soils should not be allowed to depart too far from virgin conditions. He pleads that arable soils should be under rotations in which they could be periodically renewed in structure, organic matter and mineral content, under pasture ley.

The book withal is very readable, and can be recommended to those without any great technical knowledge who have a regard for the soil for its own sake, and who are not merely seeking some solution of a garden or field problem.

E. GRIFFITHS.

THE PHYSICAL BASIS OF MYCOTROPHY IN PINUS, by A. B. Hatch, Ph.D.

(Pp. 168, Black Rock Forest, Bulletin No. 6, Cornwall on the Hudson, New York, 1937. Price 3.50 dollars.)

In this publication Dr. Hatch has provided an excellent summary of the historical development of the study of the mycorhizal habit in plants, and for that reason alone this portion of his book should prove of value to students of the problem who have not access to the numerous references cited. The historical section is of necessity restricted, but the subject matter of each period of development appears to have been well summarized and the whole collated to form a clear picture of the development of this branch of botany.

The experimental work of the author and his collaborators, a description of which fills the greater portion of the volume, is mainly directed towards proving the theory developed by Stahl in 1900 and subscribed to by Melin (1925), that is, that mycorhizæ facilitate the absorption of mineral salts as well as nitrogen. It is shown that pine seedlings grow vigorously in pure culture without mycorhizæ when a complete nutrient is provided. This was shown to be the case with orchids by Knudson (1923), La Garde (1929) and Wynd (1933). The non-formation of mycorhizæ in a complete nutrient as noted in pure culture by Melin has been confirmed and explained on the basis of availability of the major elements. It is shown that a deficiency in any one of these elements will call forth the mycorhizal response. Convincing experimental proof of the fact that mycorhizæ stimulate root development instead of retarding it is offered, and the greater efficiency of the mycorhizal system over a non-infected root system is attributed to a greater absorbing surface. The author, in reference to the pot experiments, does not mention whether or no endotrophic fungi are present in the roots of seedlings in complete nutrient which he classifies as non-mycorhizal.

The work of Rayner (1936) with the effects of mycorhizal fungi in the development of Pinus in the heath soils of England cannot be wholly explained by the mineral salt theory, and it would appear that the type of decomposition of the organic matter brought about by the mycorhiza-forming fungi is very important in raw humus soils. It is probable that the real picture of mycotrophy is one which exhibits a fluctuating relationship between the Stahlian theory as put forward by Dr. Hatch and that indicated by Dr. Rayner. The observation by Rayner of the stimulation of short root development before mycorhiza formation takes place in raw humus soils, and which she tentatively ascribes to the action of growth-promoting substances elaborated by the mycorhiza-forming fungi, also awaits further research.

The work is a fine example of cooperative scientific effort and could not have been carried out except through the unselfish attitude adopted by workers at the various institutions where researches were made in Europe and America. Throughout the publication this fact is stressed by the author, who has thus been able successfully to dovetail the results obtained by the various institutions concerned. It is to be hoped that this spirit of cooperation will be continued so that further advances may be made.

H. E. Young.

Personal Notes

New South Wales.

Professor R. D. Watt departed for England in January on six months' leave of absence. Dr. W. L. Waterhouse is acting as Dean of the Faculty and Professor of Agriculture during his absence.

Mr. W. D. Leech, Director of the Food Research Laboratories, Cooranbong, sailed for the United States in January, where he will enter upon advanced courses of study in agricultural biochemistry, particularly in relation to wheat and wheat products.

Mr. L. S. Cayzer has been appointed judge of the milling quality of show wheats for the Royal Agricultural Society of N.S.W.

Mr. E. Breakwell sailed for England early this month on long service leave. He will return towards the end of the year, via Canada and U.S.A. Whilst abroad, Mr. Breakwell will discuss with authorities the means for bringing to fruition a scheme suggested in England for an Empire Federation of Junior Farmers' Clubs.

Dr. J. G. Churchward has been promoted from the grade of Assistant Lecturer to that of Lecturer in the Faculty of Agriculture, Sydney University.

Mr. H. D. Rees departed for Tasmania in February, and has commenced duties as Dairy Bacteriologist in the Department of Agriculture.

Victoria.

It is with regret that we record the death, after a long illness, of Mr. H. C. Sewell (aged 27 years), Dairy Technologist with the State Department.

Sir David Rivett delivered the R. M. Johnston Memorial Lecture before the Royal Society of Tasmania in November last, the subject being " Wool ".

Mr. C. R. Millikan has been appointed to the position of Plant Pathologist with the State Department. Other appointments include Miss Jean Robertson, Seeds Analyst, Messrs. R. D. Anderson, Assistant Plant Pathologist ; G. W. Gayford, Assistant Horticultural Research Officer ; R. H. Hayman, E. E. Henty and C. G. Webb, Science Field Officers.

Mr. J. E. Harrison has resigned his position of Agrostological Research Officer with the Victorian Department. He has been appointed as Pastures Advisory Officer to the Australian Estates Co. Ltd.

Recent visitors to Melbourne include Prof. O. S. H. Reinecke, University of Stellenbosch, South Africa ; Prof. P. H. Wessels, Long Island Research Farm, New York ; J. W. Howie, Gatton College, Queensland ; W. T. Atkinson, New South Wales ; and J. G. Baldwin, South Australia.

Eleven persons presented themselves for the final degree examinations in agricultural science at Melbourne University recently.

South Australia.

On the occasion of the appointment of Professor A. E. V. Richardson to the Executive of the C.S.I.R., a farewell dinner was held by the Branch on February 26. An account of this function will appear in next issue.

Professor J. Davidson, recently appointed to the new Chair of Entomology at Adelaide University, is President of the Royal Society of South Australia for the current year.

Professor J. A. Prescott visited Tasmania in October last, and in company with Sir David Rivett inspected the soil work in progress. He delivered an address to the Biological Club in Hobart, and presided at the annual general meeting of the Australian Chemical Institute in Melbourne on November 15.

Mr. H. G. Poole, who was a member of the C.S.I.R. Soils Division from 1928 to 1932, has been appointed Lecturer in Chemistry at the University College, Southampton.

News has been received that Mr. E. A. Cornish has settled down well in London, and is finding plenty to keep him busy under Professor R. A. Fisher.

Tasmania.

Mr. R. H. Bevin, formerly Chief Agronomist in the Department of Agriculture, who left the State during December for New Zealand, where he has been appointed Lecturer in Agriculture at the Canterbury Agricultural College, was tendered a farewell dinner at Launceston by his colleagues in the Department.

Mr. R. A. Sherwin has been appointed to the position of Chief Agronomist in the Tasmanian Department.